The Journal

OF THE

Royal United Service Institution.

Vol. VIII. 1864. No. XXX.

Evening Meeting.

Monday, February 1st, 1864.

Colonel P. J. Yorke, F.R.S., in the Chair.

LIST of MEMBERS who joined the Institution between 19th January, and 1st February.

LIFE.

Basevi, J. P., Capt., R. E., Bengal, 2*l*; Scratchley, P. H., Capt. Royal Engineers, 9*l*; Barrow, W. P., Lieut. R. N., 9*l*.

ANNUAL.

Maclean, Allan, Cornet 1st Royal Dragoons, 1*l*.
Minty, R. G. P., Ensign 12th Hants Rifle Volunteers.
Travers, E. A. B., Major Madras Staff Corps, 1*l*.
Barron, N. J., Lieut. 2nd bat., 5th Fus.
Legge, W. D., Lieut. 2nd bat., 5th Fus.
Vincent, J. L., Ensign 2nd bat., 5th Fus.
Harison, O., Ensign 2nd bat., 5th Fus.
Manby, Chas., Capt. 7th Lan. Art. Vols., 1*l*.
Bruce, A. C., Capt. 91st Regt.

NAVAL ORDNANCE.

By Captain E. G. Fishbourne, R.N., C.B.

Mr. Chairman,—When last I had the honour of lecturing in this Institution, I expressed myself strongly as to the injustice that had been done to the service by neglecting the smooth-bore gun, and then complained that great initial velocity of projectile had been so undervalued that none of the recent guns admitted of more than very low

velocities, nor had any experiments been made with a view to obtain this very important property. There is now no room for this complaint, as Sir William Armstrong is said to have re-invented the neglected round ball, and after persuading the public that the adoption of rifling permitted guns being made lighter, on the discussion of my paper he proved that rifled guns must be heavier than smooth-bores. It might be thought that in this he had conceded the principle; this, unfortunately, is not so, for though he has partly reinstated the round ball and a muzzle-loader to fire it from, he is still constantly making changes without any real progress, because he still clings to the erroneous principles of his original design.

Assured that this entails great damage to the interests of the country, and not perceiving any hope, in the artillery experiments, of an early or satisfactory change, seeing that the apparent principle in them is only that of "working out" the erroneous system that has been so unwisely adopted, I solicit your attention while I contrast that system with those of other competitors which offer greater advantages, with a view to my defining more distinctly the gun of the future.

First allow me to run over the changes that have been made in Sir William Armstrong's guns, to show how truly I had predicted their failure.

1st. As to the multigroove. 2nd. As to the shunt.

In Plate I. Fig. 1 you perceive the early construction, the salient peculiarities of which are the coil system, (which Sir William said, in his evidence before the Committee of the House of Commons (Question 3491), was "the essential part of his system,") and the number of pieces in which the coils are put together, shown at A.A.E. G.G represent the rifling.

Then you see a great reduction in the number of coils (see lower side of gun, B); D, Fig. 1, shows a large coil put on in front of the trunnion in 1863-4; C, a piece recently cut off the muzzle; and in Fig. 3 we have his competition gun with a steel barrel, completed with a trunnion and breech coil; the object of the one being apparently as a trunnion-holder, that of the other to give weight.

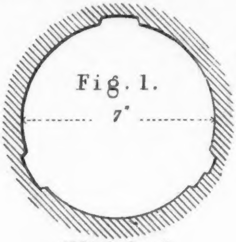
Sir William Armstrong, it will be remembered, did not agree to my criticisms on his coil system. He said that Captain Fishbourne, referring to the 110-pounder (Plate II, Fig. 6), pointed out various overlappings, stating that it must necessarily happen that the parts must draw asunder, and so on. However, said Sir William, "all that is met by the fact that it does not take place, and I need not argue the question further!"

It is very true, that steel tubes may be advisable for other reasons beyond that of the inability of the coils to stand the wear and tear upon them, which I shall have again to revert to, but I must beg your attention now to Plate I, Fig. 2, a drawing of a 12-pounder taken from the reports of the Parliamentary Committee, showing the parts drawn asunder at the opening behind the trunnions, and fractured in a line with them, leaving no need that *I* should "*argue the question further.*" I may also refer you to the guns on this system which are now to be seen in the

SKETCHES OF ARMSTRONG'S R

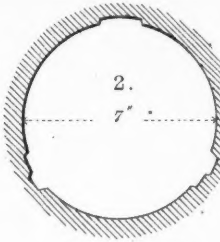
N.B. 1859 & 60. THE PROJEC

1859 to 1860, 1 Nipping Groove.



4000 Ordered
300 Supplied
About 100 Hooped

2 Nipping Grooves.



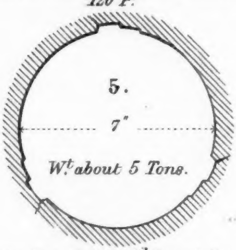
Split in Proof

MUZZ

LOADI

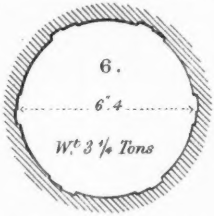
THE PROJECTILES

3 Nipping Grooves
1861, Breech and Muzzle Loading
120 Pr.

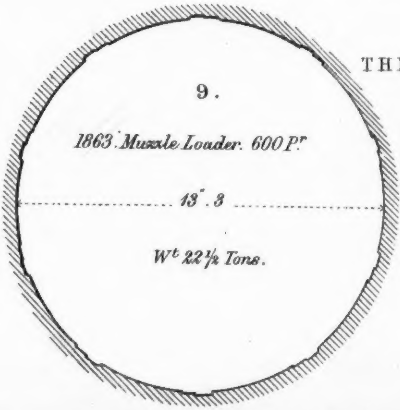


Latter Burst at 103rd Round, former repaired after 20 Rounds.

1862, Muzzle Loader 70 Pr.



Failed 283rd Round



THE PROJECTII

1863

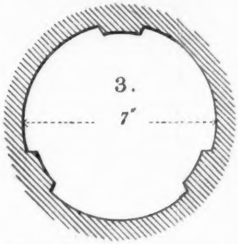
For A

NG'S RIFLING. — MUZZLE SECTIONS.

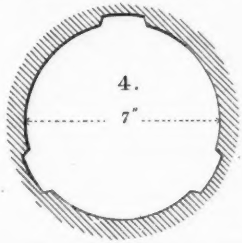
E PROJECTILES HAD IRON BEARINGS.

MUZZLE LOADERS

1860. 3 Ribs in Gun.



1861. 3 Plain Grooves.

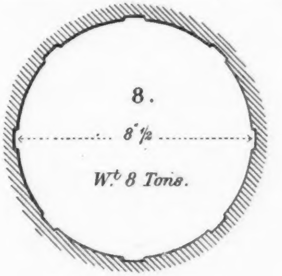


Shunt Guns were also made with Projections on the Bore and Shunts upon the Shot which were Grooved.

TILES HAD ZINC STRIPS.

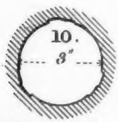
Disabled after 5 Rounds with Elongated Projectiles.

1862 & 1863, Breech Loading. 200 Pr



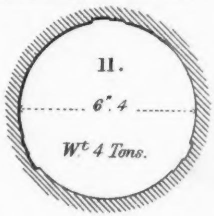
Failed after 8 Rounds

JECTILES HAVE BRASS BUTTONS.



1863 Muzzle Loader 12 Pr
Wt 9 Cwt.

1863, Muzzle Loader. 70 Pr



For Armstrong & Whitworth Competition to commence April 1864.

J.R.Jobbins

12 TON GUNS, SHOT 150 lbs. SPHERICAL, AND 300 lbs. ELONGATED.

Fig. 11a.

Coils not hooked

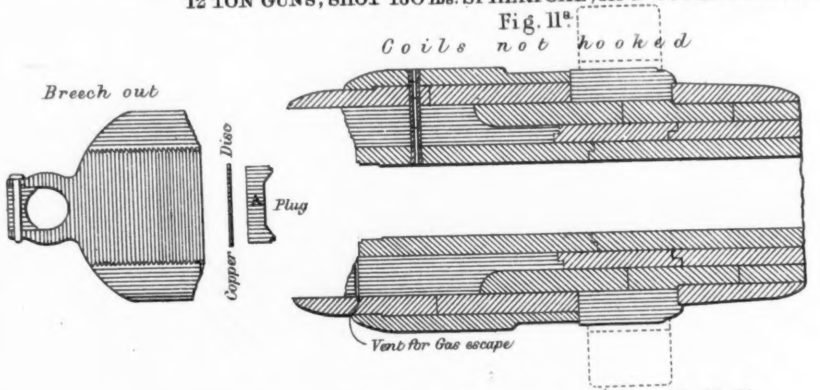
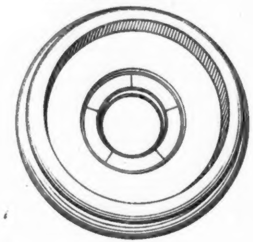


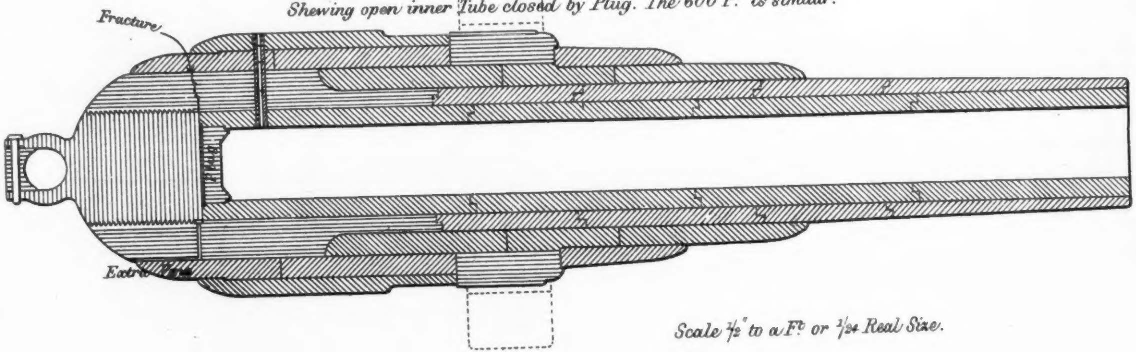
Fig. 11b.
End View of Fractured Breech.



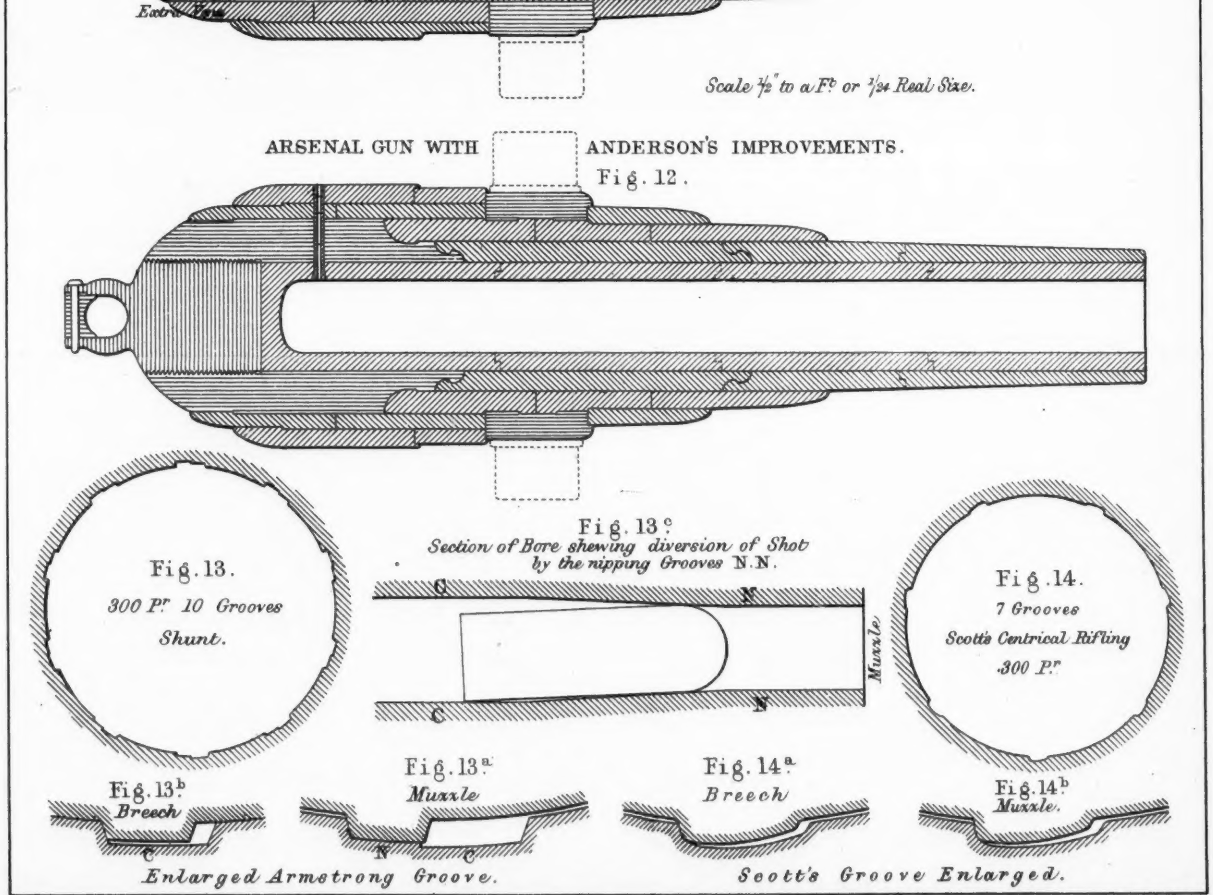
ARMSTRONG'S GUN.

Fig. 11.

Shewing open inner Tube closed by Plug. The 600 Pr. is similar.



Scale ½" to a Ft. or 1/24 Real Size.


Extra Vent
Scale ½" to a Ft. or 1/24 Real Size.
ARSENAL GUN WITH ANDERSON'S IMPROVEMENTS.
Fig. 12.
Fig. 13.
300 Pr. 10 Grooves
Shunt.
Fig. 13c.
Section of Bore shewing diversion of Shot by the nipping Grooves N.N.
C
N
C
N
Muzzle
Fig. 14.
7 Grooves
Scott's Centrical Rifling
300 Pr.
Fig. 13b.
Breech
C
Fig. 13a.
Muzzle
N
C
Fig. 14a.
Breech
Fig. 14b.
Muzzle.
Enlarged Armstrong Groove.
Scott's Groove Enlarged.
J.R. Jobbins

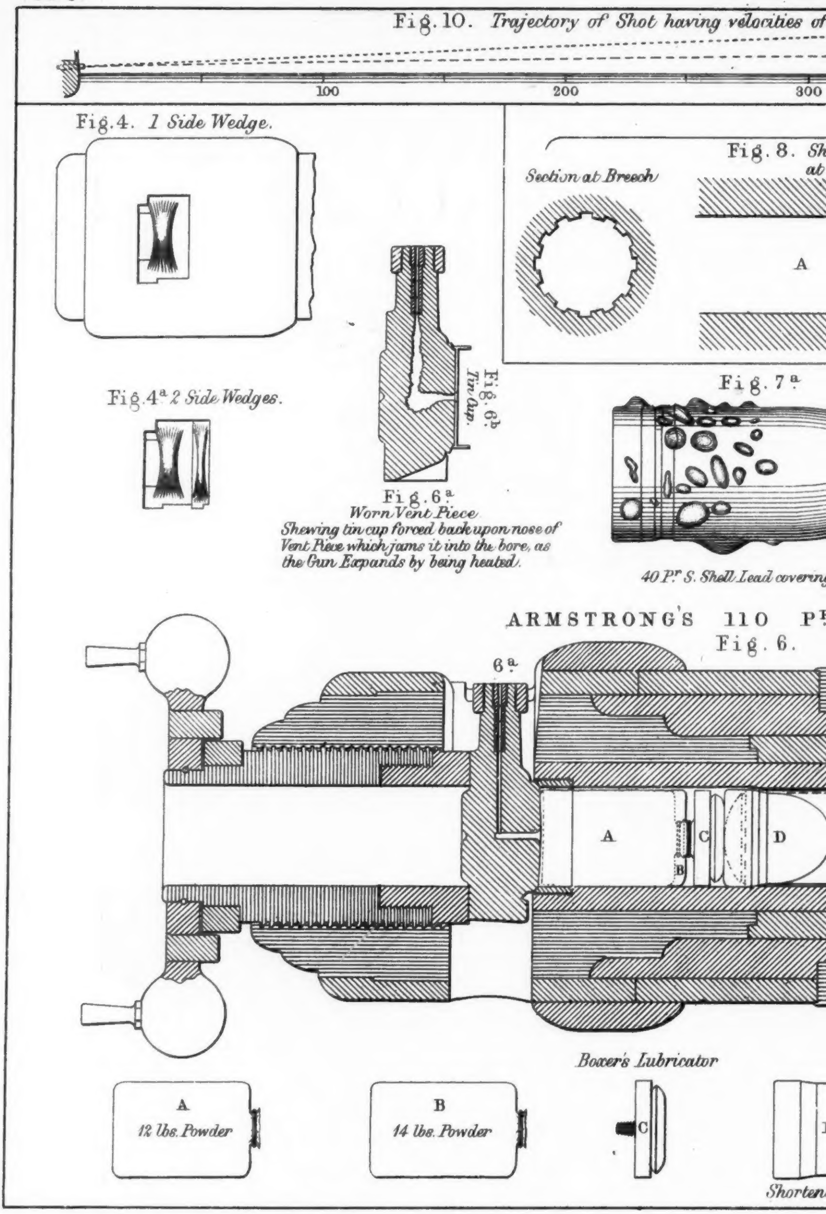
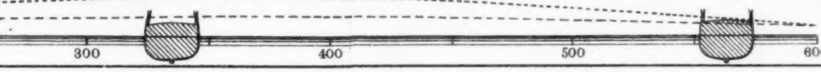


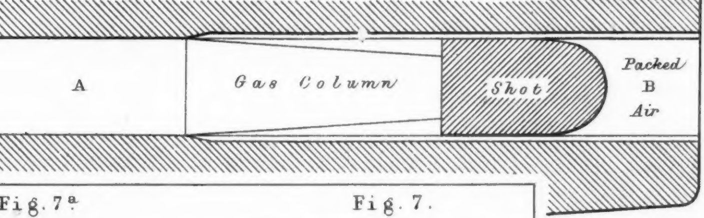
Fig. 10. Trajectory of Shot having velocities of
100
200
300
Fig. 4. 1 Side Wedge.
Fig. 4a 2 Side Wedges.
Fig. 6b Tin Cup.
Fig. 6a
Worn Vent Piece
Shewing tin cup forced back upon nose of Vent Piece which jams it into the bore, as the Gun Expands by being heated.
Section at Breech
Fig. 8. Sh
at
A
Fig. 7a
40 Pr S. Shell Lead covering
ARMSTRONG'S 110 Pr
Fig. 6.
6a
A
B
C
D
Boxer's Lubricator
A
12 lbs. Powder
B
14 lbs. Powder
C
Shorten

velocities of 300 and 600 Yards per second respectively.



ATWATER GUN. (American.)

Fig. 8. *Shewing how velocity is increased by deepening Grooves at Muzzle to allow Shot a freer exit.*



Section of Muzzle

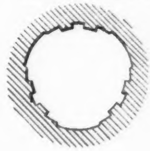
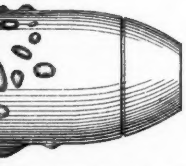
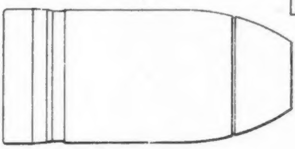


Fig. 7ª.

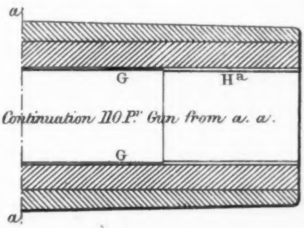


...ll Lead covering Puffed out.

Fig. 7.

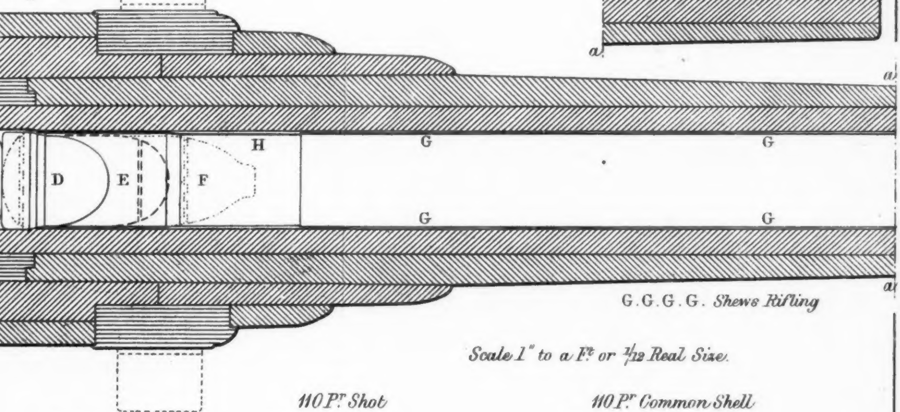


40 Pr. Segment Shell.



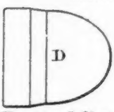
110 Pʀ. BREECH LOADER.

Fig. 6.



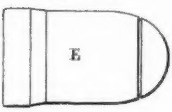
G.G.G.G. *Shews Rifling*

Scale 1" to a Ft. or 1/12 Real Size.

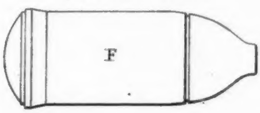


Shortened Shot

110 Pr. Shot



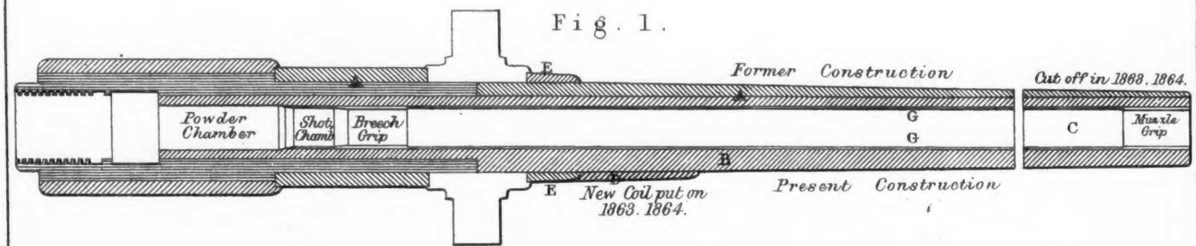
110 Pr. Common Shell



J.R. Jobbins.

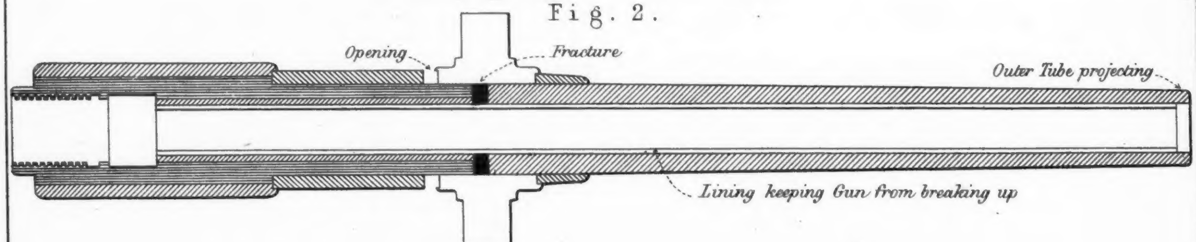
ARMSTRONG'S 12 PRS
BREECH LOADERS.

Fig. 1.



Lined Gun.

Fig. 2.



MUZZLE LOADERS.
For forthcoming Armstrong and Whitworth Competition

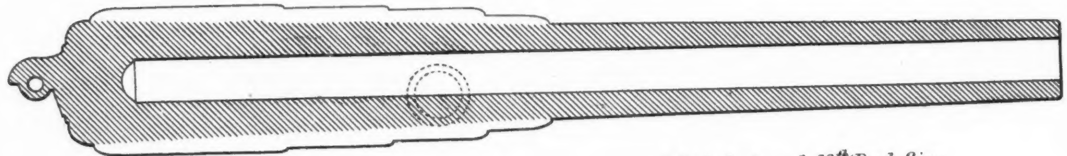
Gun with Steel Barrel.

MUZZLE LOADERS.

For forthcoming Armstrong and Whitworth Competition

Gun with Steel Barrel.

Fig. 3



1 Inch Scale or 1. 12th Real Size

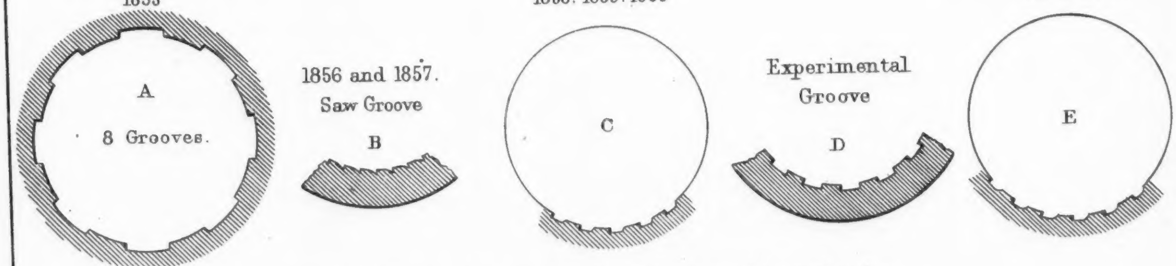
SKETCHES OF VARIETIES OF
ARMSTRONG'S MULTIGROOVE RIFLING FOR BREECH-LOADERS.

For Shot Lead Coated

3 Pr Shot all Lead
1855

Patented Groove.
1858. 1859. 1860

Groove adopted for H.M.Service
1861. 2. 3.



A Type of Gun designed to supersede the ponderous Artillery used at Sea.
(See Sir William Armstrong's Letter to "Times.")

JR Jobbins

Arsenal, to satisfy you how dearly bought has been the experience which has led Sir William to adopt other than "coiled iron" tubes, notwithstanding that he had asserted their "*inferiority*."* In the multigroove, Plate II, Fig. 6, you see the service plan of closing the breech. Fig. 4 shows the earlier plan with one wedge; and Fig. 4a, the present mode, viz., of substituting two wedges for the *breech-piece*, improperly called a vent-piece.

I will not detain you with a description of Sir William's varied plans of multigroove rifling, of which the most important are shown in Plate I, Figs. A, B, C, D, E, nor tire you with a long list of unsuccessful fuzes, costing thousands of pounds, or with an enumeration of the numberless changes in the patterns and also in the material of breech-pieces, bouchings to stop the leakage of gas, wads to prevent leading of the grooves, breech-screws and sights; together with the vast quantity of special tools necessary to keep these in order, all arising out of the erroneous principles involved in the original design.

The various charges of powder and shot are shown in Plate II, by letters A, B, D, E, and F, with Boxer's lubricators C, together with the spaces occupied by each when in the gun, Fig. 6.

I shall, however, have to advert hereafter to a few more changes,† meanwhile, we may examine the "shunt" in the varied phases of its career. In Plate IV, Fig. 1, you see the germ of the system in 1859, *one* nipping-groove only; obviously *that* could not succeed, for it drove the shot all on one side. In 1860 (see Fig. 2), we find *two* nipping-grooves with iron bearings for the shot to travel on, then we have plain projections *upon* the bore, Fig. 3, and then plain grooves *in* the bore, Fig. 4, then in 1861 we have *three* nipping-grooves, Fig. 5, and for the first time after two years' firing, *soft metal* bearings.

Fig. 6 shows a 70-pounder with six grooves, and Fig. 11 a lately finished 70-pounder with only three grooves, which looks like a retrograde step; yet three is the number adopted in the competitive 12-pounder shunt-gun with a solid barrel, represented in Fig. 10.

From the projectiles with hard metal bearings, with one row of studs to take the muzzle-squeeze, we pass to shot entirely of iron, then to zinc strips for bearings, and from zinc strips to brass buttons—changes sufficient surely to have suggested that there was something palpably wrong. I therefore need not dwell longer upon the peculiarities of the large family of the "shunts," but may be permitted to refer to my former lecture, in which I pointed out that the smooth-bore gun and the rifled-gun had not been compared on equal terms—that no just estimate of their relative values could be arrived at till "equal genius" had been expended in developing the properties of each class of gun,

* Sir William Armstrong says, "I was compelled for a time to make the inner tubes, contrary to *my principle*, from a solid forging instead of from coiled iron, and the result has proved the inferiority of the plan."—E. G. F.

† All Sir William Armstrong's plans of breech-loading have failed, as was virtually admitted in the adoption of muzzle-loading guns; and his application of the coil construction has likewise proved as unsafe in practice as the mode of its application was wrong in principle.—E. G. F.

and yet the vicious inequality then complained of, is still persisted in, to the great injury of the public service.

I remarked in my former lecture on the great difficulty of obtaining accuracy with rifled ordnance, on account of the necessary unsteadiness of ships at sea, but I *did* not urge anything against the utility of large powder capacity and long range for breaching and destroying at great distances, though Sir William Armstrong in replying to my observations, implied that I had done so.

The comparative flatness of trajectory of the round ball at short ranges, as compared with that of the rifled shot, arising from the greater initial velocity of the former, was established together with its greater general effectiveness at sea from the same and from other causes —see Fig. 10, Plate II, wherein it is shown that the round ball would hit any object not less than 12 feet high at any part of the trajectory, while the rifle ball would pass over objects more than 40 feet high.

The enormous tension that must be occasioned by the alteration which has to be effected in the lead coating of the multigroove shot, and by the nip at the muzzle both of the multigroove and shunt guns, was pointed out, and I stated that the smallness of the recoil of the former guns was no proof that there was little friction, but the reverse, for it was the intensity of the friction of the shot in passing out which prevented the recoil of the gun, and absorbed a large portion of the force that ought to have been employed in giving a higher velocity to the shot.

I dwelt on the injury it was to a naval gun to have the shot detained, as in the multigroove rifled gun.

I insisted that instead of making the pure rifled gun all and all, giving up the "substantial advantages of low trajectory, straight ricochet, smashing force, simplicity and economy for the very, occasional advantages of long range, we should make round ball firing, the basis of our system, adding such a rifling as would not interfere with it, but give us the desirable advantages of rifled guns and their capacious shells, without sacrificing any of the enumerated advantages of the round ball."

This I stated would exclude all multigroove guns, or those with a *sharp edged rifling*. I pointed out some of the most glaring defects of the coil system, of the lead-coating system, and of the strip system, and after reviewing the other rifled guns proposed by different inventors, concluded that the system of Captain Scott, from the simplicity and indestructible nature of its projectiles, from its capability of firing round balls and all other missiles used for guns, was the best suited for naval purposes.

My lecture was given in May, 1862, and the notice therein of the various systems will render unnecessary further mention of them, except so far as may be requisite to illustrate the principles set forth in this paper. As so much has been given up, it might be said that nothing remained to object to; but the fact is, that though the changes have been those merely of detail, the erroneous principles involved in the design, both of the gun and the missile, are retained, and carry with them all their pernicious consequences.

Some of our ablest artillerists never accepted Sir William Armstrong's systems as correct; some are now of opinion that the multigroove is a failure, and that this will soon be generally acknowledged, we are led to conclude, from the admission of admirers of the systems in speaking of their limited performances when used against iron plates at very short distances. To use their own language, they say, they are "quite insignificant," "almost inappreciable," and the effects produced by the 120-pounder shunt-gun, the same authorities confess, were "*not much more.*"

The many shifts in the shunt rifling and the hesitation to adopt that system in the army, indicate an opinion in the minds of the inventor and his admirers that it is not adapted for that purpose. But as there are a few influential persons who still cling to Sir William Armstrong's systems as if they thought neither of them radically bad, it will be necessary for me to prove that they each so extensively violate mechanical and artillerist principles, as not to admit of effectual improvement, and that a continuance of the use of either cannot fail to end in disaster.

The problem is how, with the limited strength and limited endurance of metals, together with the necessity for limiting the weight of ships' guns, and their projectiles, to obtain the greatest effectiveness, or how, with a given sum of money, to obtain a gun, that under the varying circumstances of warfare, will effect the greatest damage.

Viewing the subject practically, we are bound by several conditions:

1stly. That the distances at which naval actions will be fought are constantly altering, and cannot, therefore, be accurately measured. They will, however, be generally much within 2,000 yards, and only exceptionally above that distance.

2ndly. That with a given weight and strength of gun, and weight of projectile, the highest relative velocity, and the quickest exit of shot from the gun, should be provided for.

3rdly. That the gun should possess the capability of being used with spherical, as well as elongated shot, without injury to the grooving, and be also able to fire molten iron shells, grape, canister, &c. These capabilities are little short of *indispensable* where only one or two guns are carried by vessels.

If a correct mode of procedure be adopted, these conditions are easy of attainment, and then every other quality, in the necessary degree, may be given; but it will be impossible fully to meet them, unless the size and form of the projectile be such "that it will only occasion the *least tension on the gun.*"

Time and tension enter largely into almost every artillery question, yet most unaccountably they seem to have been altogether overlooked by those who, for the last few years, have had control in artillery matters in our country; for this, amongst other reasons, time and tension should have our first consideration.

The more slowly motion is at first communicated to the projectile, and the less it is obstructed afterwards, the less will be the tension upon the gun.

We know that a pressure of about 7 tons per square inch applied,

uniformly over 8 feet of a smooth bore, will give an ordinary round shot 1,600 feet of initial velocity:

7—7—7—7;

but the amount of power required to produce any given velocity of projectile will vary much as it is well or ill applied. The greatest results would be obtained by applying the pressure slowly at first, and afterwards in an increasing ratio for the purpose of accelerating the shot.

Afterwards the *order* of the pressures in this case might be somewhat as represented by the numbers:

3—6—9—12.

By such an adjustment of the pressures a much higher initial velocity might be obtained, as the power would be greater, and yet the gun would be less strained, as the higher pressures would be employed only when the shot was receding fast from it, and so relieving the gun. This arrangement, nevertheless, is neither applied, nor sought to be applied, in any gun extant, while in respect of some ordnance, it is so much violated as to occasion rapid deterioration and early destruction.

In practice the nearest approach to this application of the pressures is in the old smooth bore, in which there is a large amount of windage that prevents much of the sudden tension that would otherwise arise from the mode of igniting its large powder charge. The application of the pressures in the smooth bore may be represented by the numbers:

5—11—8—4

A considerable reduction of windage, say from ·21 to ·08 inches, would give an equal velocity with $\frac{1}{4}$th less powder, or a greater velocity with an equal quantity, but occasioning greater initial tension. The pressures in this case may be represented by the numbers:

6—11—8—4.

A rifle projectile of the same diameter as the round ball, but double its weight, and relieved in some measure by windage, will produce a very much greater strain upon the gun, in consequence of the detention of the shot by its rifle wings, and its greater inertia. These causes give time for a larger portion of the charge to be converted into gas than in the smooth bore, before the projectile moves and relieves the strain. The order of the pressures in this case would be somewhat as below, varying, of course, with the angle of twist, &c.:

8—12—6—3.

A rifle projectile, on the expanding principle, and double the weight of the round ball, would occasion still more tension on the gun, as there would be no windage to relieve it, for the projectile on its leaded base being driven out into the rifle grooves and tightly closing the bore, would, from the great friction this occasions, be moved with difficulty. More time would, therefore, elapse, and a greater portion of the powder would be converted into gas before the projectile was in motion, than in the case of a rifle shot *with windage*. An approximate estimate of the tension in this case is given by the numbers:

10—12—6—3.

But of all the projectiles extant, that which is more than double the weight of a round ball of the same diameter, and is of a diameter greater than the bore, involving the necessity of its cutting its way

through the rifle grooves, and is subjected to a sharp squeeze at the muzzle, must, of necessity, occasion by far the greatest tension upon the gun. This cannot be placed at a lower pressure in tons per square inch than the following numbers represent:

$$18-9-4\tfrac{1}{2}-2\tfrac{1}{4}.$$

The last estimate has reference to the multigroove, and the proof of the high tension is to be found in the following:—

1st. Mr. Bashley Britten's gun, with an expanding rifle projectile, and a charge of only $\frac{1}{10}$th the weight of his shot, gave an initial velocity of 1,209 feet per second, while Sir Wm. Armstrong's multigroove projectile, with a charge of $\frac{1}{8}$th its weight, attains no higher velocity than from 1,140 to 1,200 feet per second; that is, Mr. Britten's shot, in attaining the higher result, does not occasion to the gun so great a total strain as that of Sir Wm. Armstrong by *at least* $\frac{1}{4}$th, while the initial strain on Sir William's gun must be double that on Mr. Britten's.*

2nd. One of the Parrot rifled guns, a muzzle-loader, with an expanding projectile, gave an initial velocity of 1,254 feet per second, with a charge of $\frac{1}{10}$th the weight of its shot, and other American guns have given 1,244 feet with charges a shade more than $\frac{1}{10}$th.

That I have rather understated the tension occasioned by the multigroove shot is clear from Sir Wm. Armstrong's own words, in answer to questions put to him by the Defence Commission. He said, "If you fire a long shot with a heavy charge, you attain a point at which the material begins to crush, the metal in the chamber yields to the pressure, and is displaced; the gun begins to loose its form;" and again, he replies, "1,200 feet is the proper initial velocity."

Although costly coils of wrought-iron, capable of standing a compression of 17 tons to the square inch, are *necessitated* by the use of Sir Wm. Armstrong's projectile to obtain even this *low* initial velocity, it should be borne in mind that merely common cast-iron guns were used in the trials by Messrs. Britten, Haddon, Jeffrey, Lancaster, and Captain Scott, and the tension that such guns are considered capable of bearing with safety, does not *exceed* 12 tons per square inch.

Serious evils likewise arise from the projectile of the multigroove being made larger than the bore, through which it is detained in the gun, and greater heat is given out by the more immediate combustion of the cartridge in the chamber. This rapidly warms the inner tube, which does not readily part with its heat again, the consequence is, that portions of the lead-coating of the projectile are melted, and roll in small globules along the lower grooves of the gun, fouling the rifling, and, consequently impairing the accuracy of the firing.

In addition to the excessive initial tension, there is a violent strain arising from the squeeze at the muzzle,† both in the multigroove and

* In fact, the pressure of forcing a 25lb. Armstrong shot *slowly* through the bore by mechanical means is said to have exceeded 40 tons.—E. G. F.

† The effect of these constrictions is that sometimes the shell bursts *in* the gun, damaging the rifling, sometimes near the muzzle, to the danger of friends. This

shunt-guns, tending to pull the chase from the breech. This is so excessive, as sometimes to split their muzzles, and it has the peculiar disadvantage of checking the motion of the projectile just at the place where, as already shown, the greatest acceleration should be given.

These squeezings at the muzzle and breech of the multigroove, and the danger of such pressure crushing up the shells, effectually prevent, without further complication, the firing of molten iron. The muzzle squeeze in the shunt-gun is equally dangerous,* but the higher initial velocity, with equal charges, obtained from this gun, indicates the greater detention and friction of shot in the multigroove, and, therefore, the higher tension upon the gun. At my last lecture, in 1862, it was asserted that both the multigroove and shunt could be fired with as much safety as the smooth-bore, with charges $\frac{1}{4}$th the weight of their shot, and that, therefore, the strain caused by these methods of rifling could not be so great as I then represented it. Experiments were accordingly made, and the result was, that all the heavy guns which were fired even with smaller charges than $\frac{1}{4}$th the weight of their *proper shot*, were put *hors de combat*.

1st. The 110-pounder multigroove, was rendered unserviceable by firing a 100 lb. shot with 25 lbs. of powder, a great portion of the vent-piece was driven to the rear, and the remainder so jammed in, that they were obliged to blow it out from the muzzle. The lands of the rifling were flattened, the coils of the gun split, and the breech damaged.

Next, the usual 126 lb. shunt-shot was reduced to 98 lbs. weight, and fired with $24\frac{1}{2}$ lbs. of powder, from the 120-pounder shunt-gun (Fig. 5, Plate IV), which was so damaged at the breech as not to be worth repairing.

On the failure of the large multigroove and shunt-guns, built on the Elswick coil principle, to stand charges of one-fourth the weight of the shot reduced for them, the ground was changed, and very exceptional experiments were made with useless shot—useless because they turned over and gave no accuracy.†

arises from the shell starting with considerable velocity, on which the hammer inside the fuze is liberated and falls back, partaking of the shell's velocity, when this is checked by the squeeze, either near the breech or muzzle, the hammer moves forward, ignites the powder, and bursts the shell. This always takes place in the multigroove if the shot is not jammed home against the nip. The fact is so well known by those who understand the intricacies of the gun that they seldom load it when *elevated*, which in chase would entail a constant alteration of elevation, and corresponding uncertainty of fire.—E. G. F.

* A breech-loading shunt-gun, of 8 tons weight, was so much bulged in the bore by the tight-fitting zinc projections on the shot, that, after only eight rounds had been fired with 30lbs. of powder and a 150 lb. shot, it became unserviceable. —E. G. F.

† Major Mordecai's careful and scientific experiments shew the velocity of the American smooth-bore 12-pounder, with a charge of one-fourth the weight of its shot, to be 1,759 feet per second; allowing, then, for the loss by the difference of windage, and for the difference of eleven calibres, by which Whitworth's gun was longer than the American, and also for the closed windage and the less length of Sir William Armstrong's gun, we, according to Major Mordecai's formula, get the following :—

The value of these when fairly estimated according to their striking velocities, as compared with those of round shot, are given below,—

Value of the round shot as compared with Whitworth's, as 50 to 42.

Value of the round shot as compared with Sir W. Armstrong's, as 44 to 35.

Apart from the fact that such rifle projectiles were utterly unfit for service, no allowance was made in the experiments for the inequality of tension upon the guns, which was considerable according to Sir William Armstrong's own statement, for he says that "holding back the projectile" (by the rifle grooves and by the contraction in the chamber), "until the powder is converted into gas, gets a higher pressure upon the projectile," and therefore I add necessarily a higher pressure on the gun also. Then Whitworth's 12-pounder not having a constricted chamber like the multigroove, should have been given a larger powder charge, and the smooth bore being without either rifle-grooves or constricted chamber, should have been fired with a still larger charge, before any fair comparison as to the relative velocities of shot fired from rifled guns and from smooth-bores could have been instituted.*

I further showed, in May, 1862, that owing to the distances at sea being unknown, the greatest accuracy and the greatest damage to iron plates could only be effected by the highest velocities of projectile; the endeavour to adapt short shot to the Armstrong guns is an admission of the truth of this.

The figures contained in the following Table, compiled from those given in the Appendix to the Defence Commission Report, clearly show the importance attached to high velocities, while they afford another proof of the total disregard of all fair conditions that characterise the comparisons of smooth-bore ordnance with Armstrong guns. This table is given by me to show how fallacious are the views that have been made the basis for conclusions affecting great national interests.

American 12-pounder, smooth-bore..	1759	
Loss by difference of windage	150	
" " calibre	121	= 2053 against 1900 feet initial velocity of the Whitworth.
And again the same—		
American 12-pounder	1759	
Loss by difference of windage	173	
" " calibre	16	= 1916 against 1746 feet initial velocity given by the Armstrong 12-pounder, with charges of one-fourth the weight of these special shot.

And the public were told that these velocities were greater than could be obtained from the smooth-bore. The public were not told that these exceptional velocities were obtained with plaything shot; nor were they told of the difference of tension, the difference of windage, and the difference of the length of the guns, though each of these influence considerably the amount of initial velocity.—E. G. F.

* Such experiments only serve to mystify; for, with such shortened shot, long range, and accuracy, which alone could justify a departure from the simplicity and other exclusive properties of the spherical ball, are lost; in fact Sir William

Nature of gun.	Weight in lbs.		Initial velocity.	Remaining velocity.			
	Powder.	Shot.		200 yards.	1000 yards.	2000 yards.	
150-pounders, 10½-inch smooth bore......	50	150	1766	1624	1200	925	By experiment.
300-pounders, 10½-inch rifled gun........	75	300	1715	1665	1425	1215	
300-pounders, 15-inch smooth bore......	80	300	1750	..	1150	..	
600-pounders, 15-inch rifled gun........	62	600	1100	..	..	812	0·7 windage.

The tables from which the above is extracted have the appearance of being a record of facts, yet they are but speculations.

And while the 150-pounder is said to be fired with a charge of only 50 lbs. of powder as a 10½-inch smooth-bore, a 300-pounder 10½-inch rifled gun, which is exactly of the same weight and strength, is to be fired with 75 lbs. of powder and a 300 lb. projectile!!

That is, weakened so far as rifling does weaken, this wonderful piece of ordnance is by this process deemed to have been made strong enough to bear a strain with a rifle projectile *upwards of three times* the amount that was considered sufficient before it was rifled; and even to this greatly increased strain a large addition must still be made for constriction of chamber and muzzle squeeze in the multigroove, or for muzzle squeezing, if it be a shunt-gun. Again the so called 15-inch, which is but 13·3, is to be fired with 80 lbs. of powder, with a 300 lb. round ball, yet this very same gun, directly it is rifled, is deemed capable of withstanding the strain of a 600 lb. elongated shot, with 62 lbs. of powder.

If the proper charge for this gun with a 600lb. shot is 70lbs. of powder, the quantity it has lately been fired with, then the equivalent charge with one spherical shot would be 140 lbs., yet it was fired with this shot, and only 70 lbs., indicating either a total disregard of artillerist principles, or else one of the great defects of the shunt system, the inability to sustain firing round shot with proper charges, without injuring the sharp edges of its rifling.

The fancies of this table, as contradistinguished from the facts of experiments, show how great has been the delusion as to the value of the Armstrong coil-guns.

The vaunted 150-pounder smooth-bore was *proved* with a single charge of 70 lbs., one of 80 lbs., and one of 90 lbs. of powder, which is rather under the proper proof charge, but it was so strained that it

Armstrong himself stated that he could not obtain any degree of accuracy with rifle projectiles under 2¼ diameters long.—E. G. F.

Since this paper was read, another shunt-gun, with an inner tube of steel has been burst in the proof!!—E. G. F.

soon afterwards burst with 50 lbs. of powder, and a spherical shot, fracturing and blowing its breech a great distance to the rear. Plate III, Figs. 11, 11a, 11b.

Coil guns are said to be repairable, so this gun was put through some such operation, and was then fired with a spherical shot with the modest charge of 45lbs., and was again cracked under a strain about *one-fourth of that which this Table represents it as capable of bearing.*

Another 150-pounder rifled on the shunt principle was fired both with 150 lb. round balls, and 300lb. elongated projectiles, with *only* 35 *lbs.* of powder to *test* the power of endurance of the Bellerophon target against the heaviest guns, prior to constructing a new class of ironclads, that is, this *very important national experiment* was made with considerably less than half the charge which, according to the above Table, is the proper one for a coil 12-ton gun. The initial velocity of the 300 lb. rifle projectiles fired on this occasion was said to be only 1,100 feet per second, instead of 1,715 feet given in the Table, and therefore the striking velocity would be as 18 only, instead of 43!

It is clear, then, that the target was not half tested, and that the whole thing was a mockery; the more palpably so, that the blows struck were less than would be given by shot from the American "Monitor" guns.

The following description of one class of Sir William Armstrong's guns (the 110-pounder) will give some idea of the evil of his rule:—

Plate II, Fig. 6, shows a section of a multigroove showing that it, like all the service breech-loaders, is held together merely by the tightness of the outer coils, which are shrunk on over the inner coils.

Plate III, Figs. 11 and 11a, show the general formation of 10 guns of 12 tons each (10½ inches bore), in which will be perceived the loose breech-plug, A, with copper disc behind, which latter necessarily crushes up. To remedy the evil of thus weakening the breech, there is a hole made in the rear of the gun to allow an escape for the gas that passes the plug.

Plate II, Fig. 6a, is a sketch of a vent-piece in which the reaction from the explosion of the charge, owing to the detention of the shot, aided by the fire from the detonating tube, has eaten out a large cavity at the angle in the vent, which would retain the moisture either from the discharge or from rain, and would likewise catch any burning matter from the discharge, that might ignite the next charge prematurely, or the moisture prevent its ignition at all.

This form of vent-hole also materially weakens the vent-pieces, and they not unfrequently expand and become fixed in the gun; they are sometimes fractured in the use of only blank cartridge—a sufficient ground, in the estimation of practical men, to have prevented the adoption of the gun.

Another evil of this double vent is that much time is lost before the cartridge is ignited, and as the shot is detained by the constriction of the mouth of the chamber, slow-burning powder is used with a view to limit the danger arising from this detention. From these causes a

much slower discharge of the missile takes place than in the smooth-bore gun.

These arrangements are specially fatal to accuracy when a ship is rolling, for as the quantities are all unknown, any correct allowances in action are simply impossible.*

The projectiles, also, are subject to rapid deterioration; the Elswick shot are already being releaded in the Royal Arsenal,—a process about as expensive as melting up the old and making new shot.

The form of this decay is shown in Plate II, Fig. 7a, which was drawn from an actual 40-pounder shell—Fig. 7 shows the original shell. Such projectiles would of course be too large, from the large blisters on them, to be put into the Armstrong breech-loader—a gun which unfortunately cannot fire any other kind of projectile.

Added to these disadvantages, are those arising from the mode of loading; a chamber the size of a special charge, and a formation that necessitates the use in the 110-pounder of tin saucers, that require to be changed every round, and which, if $\frac{1}{1000}$th part of an inch out of gauge, will occasion mishaps with the gun; from which an idea may be formed of the straits that are likely to occur to officers all over the world where these guns are.

Owing to the detention of the shot until, to use Sir William Armstrong's own words, "the whole of the charge is converted into gas," the gun is subject to a tension *indefinitely large*,† hence the metal of the chamber is crushed up with even low charges, and with high charges the gun is at once destroyed.

The evil effect of even a 12lb. charge is seen in Plate II, Fig. 6b, where from the stretching of the rear of the gun, an opening was left of sufficient width to allow the tin saucer to be thrust back over the nozzle of the vent-piece, which it held fixed in the gun, necessitating the use of mechanical appliances before the vent-piece could be removed for reloading.

Again, because of the constricted chamber (Plate II, Fig. 6 H), the whole volume of the gas is, according to Sir William Armstrong, evolved before the shot starts; its velocity afterwards is merely sustained by expansion, consequently the pressure is very small where it ought, according to true principles, to be the greatest, at the muzzle, and yet at this very point the evil is increased by the shot being retarded by a squeeze, H, a.

In contradistinction to this, we find that the Americans, in the Atwater gun (Plate II, Fig. 8), cut away the lands near the muzzle to give the shot a freer exit, and obtain a range of 2,800 yards at 5° elevation, with a powder charge of $\frac{1}{6}$th the weight of the shot, while the Armstrong shortened projectile requires $\frac{1}{4}$th its weight of powder charge to attain an equal range.

The injury done by the practice of contracting the gun at the

* The Japanese report that a large number of Armstrong shells were found far up in land, having done no damage from having gone over the town.—E. G. F.

† It has been found that when powder is burnt in a confined chamber equal to its own volume it occasions a tension of 90 tons per square inch.—E. G. F.

muzzle was further proved by a French gun, which, through having holes bored in the chase, recoiled considerably less than before. Again, Sir William Armstrong's 12-pounder was not impaired in range (though so much shorter) or in accuracy, after having its muzzle, which contained the muzzle nip, blown off by its own charge.*

Plate III, Fig. 12, shows the superiority of Mr. Anderson's plan of making guns over that of Sir W. Armstrong.

It will be observed that the former have not only their coils hooked together, but have also solid-ended inner tubes, owing to which they will possess greater strength and endurance. Higher velocities, therefore, may be safely obtained from them.

From their defective mode of construction, 12 of the 12-ton guns, built at Elswick, costing £1800 each, are unfit for rifling.

Our Transatlantic Cousins are fully sensible of the value of high velocities. The following Table gives the initial velocities of some of their and our own rifled guns:—

POWDER CHARGE ONE-TENTH THE WEIGHT OF RIFLE PROJECTILES.

Name.	Initial velocity.	Strength of powder.	Windage.	Nature of gun.	Bearings.	Relative weights.
Britten	1213	1170	Nearly closed.	Cast-iron.	Lead.	
Jeffery..........	1181	"	"	"	"	
Lancaster	1149	"	·04	"	Iron.	
Parrott (American)	1254	—	Nearly closed.	Cast-iron — Jacketted.	Brass ring.	
L. Thomas	1277	1248	Nil.	Cast-iron.	Lead.	
French..........	1148	"	·12	"	Zinc buttons.	
Armstrong:—						
Shunt	1173	"	·04		Zinc stripes.	
40-pounder ...	1081	"	Nil.	Coil.	Lead.	
Initial Velocities with Rifle Projectiles in terms of weight of Powder Charge.						
Armstrong's shunt 600-pounder ..	1172	—	·04	Coil.	Brass buttons.	$8\frac{5}{7}$
Haddan	1277	1170	·17	Cast-iron.	Iron.	$7\frac{5}{7}$
Shunt, 600-pndr.	1275	—	·04	Coil.	Brass buttons.	$7\frac{2}{7}$
Parrott	1405	—	Nearly closed.	Cast-iron — Jacketted.	Brass ring.	$7\frac{2}{7}$

The American 10-inch naval guns throw shot of 125 lbs. weight, with charges of 30 lbs., and have a special charge of 43 lbs. to be used against thick iron plates. This charge has been fired from the same gun as often as 400 times without injuring it; but the brass rings of

* In consequence of the above-stated experience the muzzles of all the 12-pounder guns were ordered to be cut off.—E. G. F.

their Parrott projectiles slip over the rifling when fired with larger charges than those at present employed.

Our own experience, when lead-coated shot are fired with large charges, is similar, for portions of the lead melt, and the shot cut their way out without taking the rifling properly. These failures point unmistakeably to the necessity for seeking a description of projectile and mode of rifling, that will, with a strong gun, admit of the use of large powder charges, and consequently give high velocities.

As the shunt is different in principle from the multigroove, and also from the Parrott rifle gun, we may examine what prospect it affords of giving the high velocities required for iron-clad warfare.

Plate III, Fig. 13, shows a transverse section of a 10 groove 300-pounder shunt gun.

Plate III, Fig. 13a, 13b, show cross sections of an enlarged shunt groove at breech and muzzle, and shot, and will illustrate the action which takes place on the explosion of the cartridge when the shot is driven from the loading side of the rifle groove to the bearing side, which it strikes heavily, and then hugs closely.

Fig. 13c, shows a longitudinal section of part of a gun, from which it will be perceived that on the foremost end of the shot arriving at the incline at the commencement of the nipping-grooves, N.N., its end is raised upwards, and a new direction is given to the shot; not, however, without a resistance proportionate to the rapidity with which it is travelling.

Its new tendency, according to the first law of motion, is to continue with its whole *vis insita* in the line of motion last imposed upon it, which is to pass out through the upper side of the gun, as shown in the Figure ; and this tendency is very much aided by the increased tension brought on the gun by this action, for the shot having moved along the bottom of the bore (see CCC) till pushed up by the incline, shuts off the passage of the gas by its fore end coming in contact with the upper side of the bore, and still more completely shuts it off below by its base closing the windage at that point.

If the gun is strong enough to resist the strain of a charge large enough to give a high velocity, there is a great probability that the projectile, if a shell, will break up; or if a shot, that its brass (stud) bearings will yield before it is forced into a new direction by the upper incline, but in any case the repetition of such shocks could not fail rapidly to weaken, and prematurely to destroy the gun.

The greater the velocity of the shot the greater will be the danger of such a result, despite the softness of the stud bearings.*

As might be expected, the practical result of these nipping-grooves

* The Ordnance Select Committee report "that the shunt involves some peculiari- "ties of construction in the projectile, which, in their opinion, may possibly, at a "future period, lead to its rejection on practical grounds, however ingenious in "principle, and however successful it may be in the experimental practice at Shoe- "buryness. They allude particularly to the *ribs or studs of zinc*, of which there are "no less than 24 on the projectile of three different sizes, and requiring 24 slots for "their reception. These ribs are so disposed that the shell cannot fall anywhere on "its side without falling on some of them," and therefore injuring them, thereby preventing loading.—E. G. F.

is to pull off the muzzle. They also prevent quickness of loading the projectiles, which are liable to jamb in hasty loading.* They also prevent the use of molten iron, which in the Portsmouth experiment set the vessel on fire, so that she was burnt to the water's edge, before the fire could be extinguished. Captain Hewlett's report on the value of molten iron is conclusive.

The object of all these complications and dangerous expedients is to centre the shot; but this, as has been long since shewn, could be done more effectually by the grooving proposed by Captain Scott for large guns, and by General Boileau for small arms, and which is the simplest and most scientific of all the plans that have been brought forward.

Fig. 14 shows a transverse section of a 7 groove 300-pounder, with Captain Scott's centrical rifling.

The action of the shot in the two kinds of grooves—the shunt and Captain Scott's—are shown in Figs. 13a, 13b, and in 14a and 14b. On the explosion of the powder, the rifling of the latter having a rounded bearing, the first pressure of the elastic fluid brings the shot up evenly, raising it off the bottom of the bore, from whence it passes out smoothly and without oscillation upon, as it were 3, 5, or 7 rails, according to the size of the gun.†

The shunt-grooving represented in Figs. 13a and 13b, on the contrary, having flat sides, the shot on starting strikes against the bearing face of the groove with a blow which, if it does not split the gun after a few discharges, as in the case of the 120-pounder in 103 rounds, then the brass studs made soft for the purpose of deadening the blow are liable to be sheared off; the intense friction also from the constriction at the muzzle causes the rifling rapidly to wear, consequently accuracy of fire disappears.

The softness of the copper or brass studs upon the projectiles renders them very liable to get out of shape, so that the shot in loading cannot be got home to the cartridge.

Either from this cause or the limited windage (·04 to ·05 inches), or partly from both, the projectile of the 600-pounder stuck at the 6th round, and the gun subsequently required to be washed out after every round. In the 300-pounder shunt the same defects were found, the 3rd shell (steel) fired against the floating Warrior target burst *in* the gun—from, as was alleged, *not being home.* I ought to mention that the shell broke up in taking the nip (cutting up the bore); this is a sufficient explanation of the dangerous accident.

The sharp angles of the shunt-rifling, especially the deep corners on the loading side of the grooves, are a very great element of weakness, as metals always have a tendency to fracture at the angles.

* It is sought to provide against these evils by having a bearer fixed to the muzzle of the gun; but such an instrument is not likely to be used in action; so the shunt gun would most likely be spiked in loading by its own shot!—E. G. F.

† Fig. 14 represents a 12-ton gun rifled on this method as compared with Sir William Armstrong's, and shows that only half the amount of surface of the bore is taken out, and that no sharp edges are left, and hence Captain Scott's plan is better for firing round shot than the shunt.—E. G. F.

The ill effect of these deep corners is very apparent in the 120-pounder shunt (see Plate IV, Fig. 5), and they are very difficult to sponge properly.

The shot also oscillates in the gun, as was admitted by Sir William Armstrong in his evidence before the Parliamentary Committee, and this motion can only be prevented in this system by a tightness of fit that prevents easy loading.

The danger from this mode of rifling is shewn in the fact that many of the guns rifled on this principle have given way after a few rounds, and one gun after the 4th round.* No gun rifled on any other principle burst under 51 rounds.

Not long since, one of the 12-ton 150-pounders (Fig. 7) rifled on this system, and then called a 300-pounder, was only fired 5 times with elongated shot before its muzzle was cracked. It was also fired 3 times with spherical shot and a disproportionately low charge, and then sent to the "Excellent" for *exercise*, but *on no* account to be fired.

As the larger breech-loading Armstrongs had not been previously employed in warfare, the following extracts from letters of officers who were engaged at Kagosima, Japan, will show how little these guns are to be relied on, and the extent of their failure when fired with low charges, shows how disastrous would have been the consequences had they been fired with such high charges as the 16 lbs. occasionally used in target-practice at Shoeburyness.

Extract, November 3, 1863.—"The 12-pounder all right both days, "but the 110-pounder was a complete failure the second day. The "first day when fitted with time and concussion fuzes, we made some "admirable shots. The second day, no shells fitted with the pillar "fuze, went more than 300 yards, most burst *in* the gun, and nearly "all the shot *stripped*, some going as much as 600 yards to the left, "several of the grooves were cut out half way down the gun. Either "the poor thing is too delicate to be fired in a heavy rain for six hours, "or else the poor thing ought not to be left loaded for 24 hours in "any emergency."

Another extract.—"At all events, the second day nearly all the "110-pounders were useless, but the 40-pounders went all right. "Most of our work was done in from 200 to 400 yards, so that by "musketry we drove them away from the guns, knocked the guns "over with shot, and blew up the magazines with shells and rockets. "The Japanese shots at 2,300 yards with 80-pounders and 130-"pounders were excellent. We hope to get a real heavy gun instead "of the Armstrong, 'a *solid* 68-*pounder pivot*.' They are the best "guns out."

Another extract, November 20, 1863.—"In the 'Euryalus' 110-"pounder pivot, one vent-piece blew out, and one from a broadside-"gun, which split and stuck inside, knocked down the gun's crew, "but did no damage. In us the pillar-fuze and common shell burst "prematurely every time, taking five inches in length of rifling out of

* And yet it was gravely asserted that they could be used with charges of one fourth the weight of their shot.—E. G. F.

"the gun amidships right round, and going half an inch into the "metal of the gun. Every shot fired afterwards, stripped. The "'Perseus,' 40-pounder pivot, blew out a vent-piece. The 'Race-"horse's' abuse their gun horribly, and wish they had two solid 68's, "as the practice from the after gun was so superior and quicker than "that from the Armstrong."

Another Extract:—

"I am sorry to say that the Armstrong did not impress us as being "such a first-rate gun; in fact, all to a certain extent failed; a shell "burst in ours, and cut up the rifling a good deal, knocked holes in it, "a vent-piece damaged and condemned. Some few days will make "the gun efficient again. The shell with concussion fuzes, which are "brought from the shell-room and put into the gun, without being "touched, nearly all burst at the muzzle of the gun; nor can they fire "at short ranges so quickly as the old 68-pounders."

An experienced Gunnery Officer wrote as follows, respecting the behaviour of the Amstrong guns at Kagosima:—

"I have received further information on the same subject, and learn "that the defects were more than at first reported. The practice also "appears to have been worse with the Armstrongs than with the "smooth-bores."

Another Officer says:—

"It is a pretty general opinion that the 110-pounder is not fit for "sea-service or rough weather. It was blowing hard, and the first "day it rained. The 110-pounder missed fire eight times; the first "shot was not till we had been under fire 20 minutes. The 68 "missed fire only once; no accident happened to it; it was always "ready when wanted, made first-rate practice, and fired quickly. "The 110 made bad practice at close quarters, and was no better at "long shots than the 68.

"Could not get the 110-pounder off on four occasions; once not "under 28 minutes, from the vent-piece jamming. This happened "three times. The 68 knocked over 5 guns; 110 did not touch one.

"The pillar fuze failed in the Argus; one shell burst in the gun "and stripped the grooves, so that after that the shot could be driven "through the gun with the rammer; every shell after burst, and the "shot were useless. Perseus had two vent-pieces blown out of "40-pounders. Coquette's vent-pieces *jammed* three times—one time "when under fire for half an hour. The cry is 'give us the old 68's again.'"

So calmly reviewing all the facts placed before you, and others* that I have not time to dwell on, I can come to no other conclusion than, that of all the projectiles and systems of rifling that have come under my observation, and these have been many, the lead-coated shot and the multigroove gun of Sir Wm. Armstrong, are amongst the worst,

* A month after the action at Kagosima they were still trying to grind out the effects produced by the shells bursting in the guns of the "Argus" steamer. —E. G. F.

The Japanese have since reported that all the damage done was by the "*big round ball.*"—E. G. F.

if not the most erroneous in "principle," and his shunt shot and grooving, though better, are far below many others.*

I proceed now more distinctly to indicate the qualities necessary in a naval gun:—

1st. *To fire Round Ball, as well as Elongated.*—It is clear that nothing will compensate for a low velocity, especially when firing against forts or ships. To attain this, we must have either smooth-bore guns, or what is better, guns with a description of rifling that will admit of the general use of spherical shot, as well as the rifle ammunition,† such guns will not require to be kept up to the limit of endurance by firing rifle projectiles constantly, but can be used with the round ball with comparatively little strain, when this kind of shot can do the work, and the round ball is especially adapted for rapid firing at close quarters.‡

In firing, the time occupied by 7 men, running the *American* 15-inch gun to battery, depressing it from maximum elevation, sponging, loading with *round* ball, and elevating ready to fire with maximum elevation, was—

First trial, 4 minutes. Second trial, 3 minutes and 10 seconds: with gun horizontal, the time running to battery, sponging and loading, was—

1st trial,	1 minute	52 seconds;	2nd,	1 minute	28 seconds;
3rd,	1 ,,	10 ,,	4th,	1 ,,	15 ,,

500 rounds were fired, and no wear or enlargement was found.

The time occupied at Shoeburyness in firing "Big Will" varied from 20 minutes to 10 minutes each round. After *a dozen or twenty rounds it was found that the chamber had become slightly oval, and the inner tube had started.*

Nor is it matter of opinion that round shot are more effective at short ranges; it is as much a matter of law as that the elongated shot will range further.

Up to a certain short distance a round shell, if sufficiently tough, will, from its higher velocity, be more effective than a solid sphere; over that distance, and up to another, the solid sphere, from maintaining its velocity longer, will be more effective than the shell, beyond this a medium elongated shot, and then an elongated shot according to length.

It is sometimes argued that a sphere is a bad form for penetrating, but the object being to smash in the part assailed, the round ball,

* Captain Sir William Wiseman, some time Vice-President of the Ordnance Select Committee, stated, in his evidence before the Parliamentary Committee, that there were many other systems that he preferred to the shunt.—E. G. F.

† My gallant friend, Admiral Halsted, will be glad to learn that the Admiralty have ordered a number of smooth-bore guns. To make the order complete, they have but to add that these should be rifled on some good plan, that will not impair their efficiency as smooth-bore guns.—E. G. F.

‡ I am glad to be able to quote the opinion of Colonel Boxer, Superintendent of the Royal Laboratory, Woolwich, and long a member of the Ordnance Select Committee, who, in an able pamphlet, says, "If, therefore, a system of ordnance could be devised, combining the advantages of both (the smooth-bore and rifle), there could then remain no question as to its general introduction."—E. G. F.

from concentrating its blow upon a limited part, and from its leverage for fracture, is better than a flat-headed projectile; and the late results with round steel balls, which passed through 5 and $5\frac{1}{2}$-inch plates, making destructive missiles of the broken pieces of plate, justify the above conclusion.

Moreover, the rifling increases both the accuracy and range of spherical shot, as it gives them a slight rotation, and hence a definite direction.*

The idea that round shot will necessarily glance off, is likewise groundless; an elongated shot is only prevented by its rotation from turning over, consequently at the first impact it glances.

The greater the velocity the less is the chance of glancing.† An American correspondent says:—

"One round shot penetrated her after turret, speaking of the Keokuk, the sides of which it will be remembered are frustrums of cones, while the turrets of the monitors are perpendicular cylinders; another shot passed through her port bow, and still another through her starboard quarter. These were all steel projectiles of 100lbs. weight, and polished to the smoothness of a knife blade. The terrible effects of those projectiles may be imagined when it is stated that one of them striking the *after turret at an angle*, when the vessel was almost under the walls of the fort, buried itself in the iron mail, and there remains." Windage of these guns was 0·12 inches.

The very great value of high initial velocities has been quite overlooked, but proceeding on the assumption that penetration was as the square of the velocity, the value of the smooth-bore 68 was placed at 17, as compared with the 110-pounder Armstrong, which was valued at 16, and a quantity of fine writing was added by way of proving that if the fact was not so, it ought to be so. The practical answer to all this, is the hard fact that the 110-pounder penetrates at 200 yards $1\frac{6}{10}$ inch, and the 68-pounder with steel shot 4 inches, and the 100-pounder smooth-bore, also with steel shot $5\frac{1}{2}$ inches of plate, making a hole in addition, that men actually passed through.

That we have not steel shot in general use, is amongst the evils of Sir William Armstrong's rule. As early as 1859 Mr. Whitworth, by putting a bolt through the "Trusty," showed the value of steel, and in fact that it was indispensable to success against iron clads; and yet nearly all the time since then, while we, as well as foreign nations,

* This was proved by experiments made by the Ordnance Select Committee with Captain Scott's rifled guns, in May, 1860, and with Mr. Britten's rifled gun a year later.—E. G. F.

† The idea that round shot must glance has arisen from not considering the influence which the element of time and velocity exercises in all such questions. If a ball, or even a candle be fired at a door standing open, and the velocity be considerable, either will pass through the door without its moving on its hinges; if, on the contrary, the velocity be small, the door will move, because time will be given for the elasticity of the wood to act, and the candle and, it may be, the ball, will be thrown back; this is analogous to what occurs with plates of armour; if the velocity be high, there will not be time for the elasticity of the plate to act, the ball will, therefore, enter; nor does this property of penetrating more truly belong to the flat-headed shot than to the sphere, but less. *There is also no straightness of ricochet from the rifle ball.*—E. G. F.

have been building iron-clads, our arsenals have been employed in making shot for all descriptions of guns quite useless as against them; and Elswick has had extensive employment also in making these brittle shot, the result of which is, that we have now nearly a million pounds worth of nearly useless stores.

Lead-coated shot must of necessity be thus fragile, for if the metal be heated for the purpose of effectually coating them, the temper is taken away; and if not heated the shot must be undercut, and still the lead flies off on the heads of friends, instead of on foes.

The influence of time also has been lost sight of in estimating the effects of shot on plates.

A shot that enters a plate does so at a much higher rate than as the square of the velocity, but this is gradually reduced at each increment penetrated, so that after a time its velocity is so reduced, that there is not sufficient to penetrate further.

From this follows—

1stly. That there will not be any penetration through the plate, unless the projectile moves at a certain high velocity.

2ndly. That the higher the velocity, the smaller within practical limits, varying of course with the plate to be penetrated, may be the projectile that will penetrate.

3rdly. The heavier the shot, the lower may be the velocity necessary to penetrate a given thickness of plate.

4thly. That for a given weight of shot to pass through a given thickness of plate, there must be high velocity at impact, proportionate to the thickness of the plate, so that a sufficient velocity may remain to penetrate the last portion of the plate.*

The rifling of the gun should be such as will not be injured by firing round shot, and we have determined that iron bearings alone will admit of the *highest velocities*, and it is simply folly to be content with anything short of these, for as has been shown, the higher the velocity the smaller may be the projectile, and therefore the smaller and lighter the gun. The only two forms of rifling that offer are Mr. Whitworth's and Captain Scott's, but the inability to fire spherical shot and molten iron is fatal to the former, and the angles of the grooving are an element of weakness in the gun: this leaves no choice but to use that of Captain Scott, which has this further to recommend it, that the gun is much less strained, and the form of groove is somewhat like that of the French gun, from which the highest comparative results have been obtained; its projectiles also, as I mentioned in a former lecture, are little liable to injury.

Windage.—The amount of this, in various guns, ranges from ·015 to ·210, and when I pointed out the loss arising from giving the larger quantity, I was told that less could not be given without bursting the gun. The smaller quantity is preposterously small, as is that given to the 300 and 600-pounders (·040 inches), for in neither case would there be sufficient for service, for unless the gun was mopped out, as

* No estimate as to penetration at 2,000 yards by a slow moving body can be formed from the penetration effected at 200 yards by a fast travelling body.—E. G. F.

the 600-pounder was after nearly every shot, the gun could not be reloaded.

The proper quantity should have been determined long since, but it certainly should not be *less* than ·060.

The system of giving rotation by studs does not admit of sufficient windage, nor would studs admit of sufficiently high velocities, for they cut half through with the present charges; yet the 600-pounder only yielded 1170 feet initial velocity with steel shot, when fired at the floating Warrior target; yet in producing this low initial velocity, the gun has become slightly oval at the seat of the shot. There is a flaw* near the muzzle, or rather an opening round the bore, and the inner tube has also moved forward slightly.

Another advantage of Captain Scott's plan of rifling is that sufficient windage can be given. A certain amount affords facility for loading, and conduces to an easy and rapid exit of the shot. Nor is the escape of gas by the opening lost power, for it blows out the wad necessarily used at sea, which otherwise would prevent accuracy, and greatly increase the strain on the gun in firing rifle projectiles. It also drives out the air from the front of the shot, thus further relieving the gun from pressure.

2nd. *The cartridge* should be differently formed and ignited than is now the custom.

It should be ignited at the end next the shot, so that the first portions of the gas formed should start it, and the full force of the gas should act on it only when it was in motion. In a word, the powder should be burnt somewhat in the following order of time and quantity, the smallest (12, 8, 4, 2) quantity first, and the latter quantity to be of fast burning powder. The precise kind and quantity can only be arrived at by experiment.

This arrangement would, in a gun of a given strength and weight, admit of the use of larger charges or stronger powder, whether the shot were elongated or spherical, or equal efficiency, with less cost, or less weight for ships, and would avoid the danger from air space.

The Americans endeavour to obtain something like the object described by the use of cake powder, by which they effect considerable results with comparatively little strain on the guns. The powder, however, does not burn fast enough to give the high velocities required in ships' guns.

The French have long adopted a plan, the value of which has also been recognized in America as giving higher initial velocity, with less tension on the gun, though the reason they assign for this effect is not correct.

The cartridges are made up in cylinders smaller in diameter than that of the bore of their respective guns. By this the first increment of gas evolved passes over the remaining portion of the cartridge and starts the shot, before the remainder is converted into gas. The same results might be arrived at by igniting the cartridge at the fore end from the breech end, through a hollow tube in the cartridge, or better by the

* It is said now that the flaw existed before the gun was fired. It may fairly be asked why was it paid for as if perfect?—E. G. F.

substitution of gun-cotton for powder. This material seems to offer great facilities for evolving the gas at the most correct time, and in the quantity required. It possesses also other valuable qualities,—that of not occasioning smoke and not heating the gun in any degree comparable to powder; nor does it foul the bore; while it is also more regular in its action and safer to handle.

3rd. *Material.*—The Duke of Somerset asked, in May, 1862, when his Grace occupied the chair in this Institution, "whether it was proposed to give up cast iron altogether, and adopt wrought iron." This was hitting one of the great blots in the coil system, for misconception as to the action of powder, especially in the multigroove gun, led to the adoption, because of its greater strength for resisting the tension which the missiles of that gun entailed, of a metal for the interior of guns that was wholly unfitted for the purpose of withstanding the wear of rifle projectiles.

The action of powder exploding, partaking of the nature of a blow (witness the expansion of brass and of lead into grooves, and the enlargement of the chambers of guns), shows that a very necessary quality to have been sought in metal for guns was hardness. Cast iron was said not to have sufficient hardness, and that the balls indented the guns, and finally destroyed them. The American experiments established that wrought iron was more easily indented than cast iron, and for the obvious reason that the degree of hardness of the former is only 38,000 lbs., while that of the latter is 92,000 lbs. The cast iron was, therefore, better adapted for the interior of guns, and any requisite tensile strength would have been better added at the outside, as was done by Capt. Blakeley, the French, and others, or else greater tensile strength might have been obtained by improving the quality of the castings, as was done by the Americans, who, by this means, obtained more enduring ordnance than any of the Armstrong coil guns.

The strength or hardness of wrought iron under compression is equivalent to a pressure of 17 tons to the square inch, and the explanation of the cracks and flaws which are to be found in the chambers of the multigroove coil-made guns after proof, and which increase with use, is to be found in the fact that the metal has been compressed beyond its capability of endurance. In a word, *all these guns, from the time of being received into the service as sound, if in use, are in process of disintegration*, and only do not break to pieces because they either stretch, or the vent-pieces give way and relieve the gun. So that, at no distant day, they will all become mere obsolete stores, the only escape from which result will be, the use of *very limited* charges *and* a description of missile constructed on mechanical principles, instead of one designed on a plan which destroys the gun.

The decay of the Armstrong coil guns is looked upon as a matter of course, as is evident from the recent addenda* to the Queen's Regulations, which I may affirm, without contradiction, is without parallel in the history of this or any other country.

Extract from circular:—

* See also article on shot and shell, page 87 of Addenda.—E. G. F.

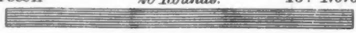
EXTRACTS FROM O.S.C. REPORT DATED FEBʸ 6ᵀᴴ 1863.

"On Competitive Rifled Cast-Iron Guns" (all 32 Prs of 58 Cwt.)

AMOUNT OF ERROR AT 5° ELEVATION.

(The practical limit of distance for Warfare)

Britten *20 Rounds.* *16th November 1859*



Mean Range 1850 Yards.

Britten *15 Rounds.* *3rd August 1861*

Mean Range 1898 Yards.

Scott *11 Rounds.* *23rd October 1861*

Mean Range 1975 Yards.

Armstrong Shunt *6 Rounds.* *25th September 1861*

Mean Range 1940 Yards.

Armstrong Shunt *9 Rounds.* *26th September 1861*

Mean Range 1952 Yards

LAST COMPETITION AMOUNT OF ERROR AT 2° ELEVATION
AUGUST 2ND 1861.

Rifling of Gun.	Number of rounds Fired previous to this Competition with elongated Shot.		Description of Shot.
3 Grooves	Scott	300	all Iron
5 D°	Britten	263	Lead on base
Oval	Lancaster	138	all Iron
3 Grooves	Haddan	63	D°
7 D°	Jeffery	51	Lead on base

Britten *15 Rounds.*

Mean Range 912 Yards.

Scott *9 Rounds.*

Mean Range 1129 Yards.

Note. *These Diagrams represent the relative space required for half the number of Shot fired to fall within them. (See Report O.S. Committee)*

J.R. Jobbins

"Whenever a flaw is discovered in an Armstrong gun, an impression "of it in gutta percha or some other available substance is to accompany the report made by the captain, together with a full description "of the position of the defect.

"Great care should be observed in reporting flaws. The gun should "be carefully examined when first received, as it frequently happens "that flaws have been reported as having been discovered after firing "a few rounds, which, in reality, existed at the time the gun was "issued.

"When the accident is with any of the parts of the gun, such as "the breech-screw or vent-piece, the whole of the marks on the vent-"piece or vent-screw should be fully described, and a drawing or "rubbing transmitted of the fracture or damage that may have "occurred."

Clearly, then, from the moment that cast iron was deemed insufficient, Bessemer's, or other steel should have been fully tested, more particularly as I observe from the reports of evidence that Mr. Bessemer offered to guarantee to supply metal that would bear a strain of 45 tons to the square inch. It is due to Colonel Wilmot to say, that he obtained the sanction of the Government to make guns of that metal as far back as 1859, and that he left in his office proofs of its value for such a purpose when he was superseded by Sir William Armstrong.

4th. *Endurance.*—Bessemer's metal, or indeed many kinds of steel,* can, by the use of the hydraulic press, be given a homogeneity, and therefore a certainty of character, quite unattainable either in coils or in ordinary iron castings.

The closeness of texture and hardness of steel admit of a smoothness of surface that will resist injury from the rapid formation and rapid flow of gases, as well as from indentation from the shot, and thus much conduce to endurance. Hardness will likewise ensure the continuance of accuracy by resisting the effect of the friction of the rifle-shot, which would wear down a softer metal.†

The extent of this evil is shown in Sir W. Armstrong's 70-pounder and his cast-iron 32-pounder guns, and also in B. Britten's rifled gun, and though the bearings of the shot in the former case were of soft metal (zinc), and the bearings of the latter, lead, neither have maintained the accuracy given by earlier discharges. (See Plate V of Diagrams of Error from O. S. Committee's Report on Competitive Cast-iron Guns.)‡

* Cast steel is less liable than any other metal in general use to become crystallised by *vibration*, which is a progressive cause of weakness in guns.—E. G. F.

† Charles Stewart, Esq., of the London and North Western Railway, says, "I cannot resist the fact that certain points where the ordinary rails wear out in a few weeks the steel rail stands the wear and tear in a most extraordinary manner. We are expending £50,000 for producing rails, &c., on Bessemer's process."—E. G. F.

‡ I must not be understood as admitting the accuracy of the representations made in any of these parallelograms. The mode of applying the theory of probabilities in them is incorrect, and is another illustration of the dilettante-ism that has been imported into this question. A true representation of the facts would still further show the greater advantages of Captain Scott's system.—E. G. F.

Round shot of Bessemer's metal and of other steel can be made homogeneous and concentric, and hence great accuracy of fire may be ensured; spherical shells likewise can be made of sufficient strength to pierce ordinary iron plates.

It should be mentioned that Mr. Michael Scott, C.E., proposes so to adjust the centre of gravity of elongated shot as to obtain accuracy and length of flight without rotation, this, if effected, will dispense with the evils of rifling.

5th. *Calibre.*—The difficulties involved in this question appear to me not to have had their due weight, and we have been hurried into the partial adoption of monster guns by Sir William Armstrong, who, finding he could do nothing with his small guns, thought he would hold his spurs by performances, obtained at a very great cost, a cost quite disproportionate to the results. Each round fired from "Big Will" is said to have cost £60, and it is doubted whether its effect was much greater than that of the 100-pounder smooth bore at Portsmouth, or certainly might be, with a better devised gun of that size. Be that as it may, there are other considerations that should be weighed.

1st. The difficulty of controlling the motion of such guns, more particularly when the ship is rolling rapidly.

2nd. The increased difficulty of loading, even with round shot. With elongated shot there would be the complication and delay of machinery.

3rd. A much more limited endurance; owing to the greater proportionate heat from large charges, and the greater inertia and friction of such proportionately heavy elongated shot, the explosion will always be more violent. The surfaces, also, per square inch, of the chambers of such guns will be subject to a greater tension, as is evident from the following table:—

Calibre of gun.	Area of equal transverse sections.	Volume of powder.	Relative proportion of powder to one inch of chamber surface.
2 inches.	6 inches.	3	$\frac{3}{6}$
3 "	9 "	7	$\frac{7}{9}$
4 "	12 "	13	$1\frac{1}{12}$
6 "	19 "	28	$1\frac{5}{9}$
8 "	25 "	50	2
13·2 "	41 "	137	$3\frac{1}{3}$

Showing that the pressure from equal proportionate charges on a particle in the chamber of a gun of 2-inch bore is vastly less than that on a particle in the chamber of a gun of 13·2-inch bore, and that, therefore, a material, and a missile, and mode of construction and of firing, that might suit in a gun of 2-inch bore would be unsuitable for an 8-inch bore; and those that would suit in an 8-inch bore might be quite unsuitable in a 13-inch or 15-inch bore, suggesting a doubt as to the prospect of obtaining any reasonable measure of endurance from

guns of very large calibre fired with charges that will give very high velocities, or velocities equal to the smaller guns.

I am strongly impressed with the belief that the 12 ton 150-pounder, if cast of Bessemer's metal, or other steel, and its strength judiciously used, by the application of well-devised missiles, &c., would be a far more effective gun than any of greater size. The results said to have been obtained from the French 30-pounder throwing 100 lb. elongated shot fully justify this view, for it is said to have pierced a $5\frac{1}{2}$ plate at 1090 yards. Whether this be a fact or not, I have no doubt of its feasibility. In the face of the facts given in this paper, I may ask what is the object proposed by the competitive trial of Armstrong and Whitworth 12-pounders about to come off? No practical artillerist would form a judgment as to great guns from the results that trial with small guns will give, nor would any practical man recommend the adoption of either system of rifling for the navy, neither being suitable for firing round shot, &c.

I have not dwelt upon the cost of large guns, nor the cost of badly designed missiles, but as all mechanical questions resolve themselves into £ *s. d.*, I ought to state that a gun similar to the French steel 30-pounder, which sent a shot through a $5\frac{1}{2}$ plate at 1,090 yards, might be made of Bessemer's metal for £100. Big Will cost £3,800, and much ado was made about its sending its shot through $4\frac{1}{2}$ inches of plate at 1000 yards.

The most ludicrous fact is that the old 95 cwt. 68-pounder, which it was known as far back as 1859, would put a homogeneous shot through a 4-inch plate, and made an indentation of $2\frac{1}{4}$ inches with a cast-iron shot, was put aside, in part, for the Armstrong 110-pounder, that only penetrates from $1\frac{6}{10}$ to 2 inches ; the Armstrong gun costing £650, the 68-pounder only £95!

I have shown that to obtain the highest results, at the least cost, the gun of the future most possess:—

1. The double capacity of firing round ball, and the elongated shot.
2. That arrangements as to vent and cartridge must be made for burning the powder to greater advantage than is the case at present.
3. That the calibre must not be excessive.
4. That the grooves must be simple and not liable to injury from firing the round ball.
5. That there must be windage of not less than ·06.
6. That the gun should be solid, and of Bessemer's metal or other steel.
7. The missiles should be of tough but hard metal.
8. The ribs on the projectile must be of strong metal, cast on the shot, and of a simple form to stand the greatest strain of rotation with high charges, be little liable to injury, and admit of sufficient windage.

In closing this paper, I submit that if we are to escape a repetition of the errors we are now suffering from, if we are to make progress henceforth, and if the confidence of men and officers in their guns, and in the judgment of those who rule in these matters is to be restored, all artillery experiments must be directed with reference to some comprehensive scheme to determine principles rather than

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7. The missiles should be of tough but hard metal.
8. The ribs on the projectile must be of strong metal, cast on the shot, and of a simple form to stand the greatest strain of rotation with high charges, be little liable to injury, and admit of sufficient windage.

In closing this paper, I submit that if we are to escape a repetition of the errors we are now suffering from, if we are to make progress henceforth, and if the confidence of men and officers in their guns, and in the judgment of those who rule in these matters is to be restored, all artillery experiments must be directed with reference to some comprehensive scheme to determine principles rather than

whether one gun shoots better than another, each placed under exceptional circumstances, and the judges must confine themselves to their proper province, and cease to be special pleaders for Mr. A. or Mr. B.

The CHAIRMAN: I am sure our thanks are due to Captain Fishbourne for this excellent paper, and for the great pains he has taken in bringing forward his views upon this subject. So interesting as it is at the present moment, I have very little doubt that there are many gentlemen present, who would like to make some observations; but it will be a question with the meeting, whether we should take the discussion now, or adjourn to another evening.

Admiral HALSTED: I think it would be more advantageous to adjourn it; I might finish my own part of the discussion simply in reply to Captain Fishbourne's remarks with reference to the 100-pounder which it is intended to rifle, by saying, that whenever we see those guns safely rifled, so as to give us the full advantage of rifled guns, in the proportion to what they now possess as smooth bores, we shall then recognise the possibility of the same gun doing the double work.

Captain LEOPOLD HEATH, R.N., C.B.: May I say a few words now, as I shall not be here to-morrow evening? My object is to put the meeting right upon some points in Captain Fishbourne's paper. Interesting as the lecture has been, it reminds me very much of what certain Commissioners did who came into the Crimea in the spring of 1855. During the previous winter everybody had suffered great hardships, and everybody had set his shoulder to the wheel, and they were getting everything into a good state, when out came this band of Commissioners; they re-touched what was going on with a little gilt here and a little paint there, and they came back and got the credit of all that had been done. I think Captain Fishbourne has been destroying things on paper, which have already been destroyed in fact. For instance, he complains that the muzzles of the guns break off because of the grip. The grip has been abolished. He complains of the undercutting of the shot. Undercutting was done away with two years ago. He complains of the simple shrinking on of the hoops. That plan is no longer used, and the hooking system, introduced by Mr. Anderson, has been substituted for it. The fact is that the state of the gun question is a state of progress; it is perfectly true that many of the defects pointed out in this gun exist; but it is also true that none of these guns are being made now, or have been made for a year. I think there may be small guns, some 20-pounders, that are being made, but nothing larger than that. Now, with reference to the Table of expansions, it is a curious Table, and I cannot understand it.

I will not go down the different lines of figures; but if any one of them could be proved to be a true representation of what takes place in a gun, it would be a most valuable contribution to the science of gunnery. Those who have tried their hands in determining the initial pressure of a given charge of powder with a given weight of shot before it, have come to most different results. I think Count Romford gave 40,000, where Mr. Robins gave 15,000 lbs. pressure. There was an enormous difference in the result of the experiments. There are experiments going on now which may, perhaps, elucidate it; a gun is being cut down, beginning at the muzzle, by successive lengths, and the initial velocity is being determined as the gun is being shortened. So far as it has yet gone, the experiment shows, that the expansion of the powder follows the law of all other gases, that it expands in the inverse proportion of the space it occupies.

The coil-tube is another instance which Captain Fishbourne gave us as a mistake. That, again, has been given up in all the recent guns, and steel has been adopted. As to Bessemer steel, it is an excellent material for rails, and it may be an excellent material for guns, but that does not follow; a railway rail has to do different work from that required of a gun.

Now, as to the velocities, I do not remember the figures, but I believe I am right in saying, that the comparative results of the two 12-pounders, the Whitworth and the Armstrong, were obtained with a Whitworth gun of 36 calibres long, compared with an Armstrong of 24 calibres, and that is not a fair comparison.

Captain FISHBOURNE: I took the fact from other people.

Captain HEATH: Now, when you take two guns, the Whitworth and the Armstrong of the same length firing the same weight of shot, and discharged by the same charge of powder, you get as nearly as possible the same initial velocity, with a little advantage on the side of the Armstrong gun. I wish it to be clearly understood, that I am not here to advocate Sir William Armstrong's system; my only object is to give you some accurate figures on the subject. Again, Captain Fishbourne tells us that the Armstrong 120-pounder shunt-gun produced as little effect upon the iron plate, or little better, than the Armstrong 110-pounder.

Captain FISHBOURNE: I beg your pardon, I quoted other authorities—admirers of the system used that language, not I.

Captain HEATH: I understood you to say, that the 110-pounder produced very little effect compared with the 68-pounder, and that the 120-pounder shunt-gun did little better.

Captain FISHBOURNE: I quoted other persons' language.

Captain HEATH: However that may be, I only wish to give you correct the figures; of course every body will understand, that all that a gun can do is to send a shot out of its muzzle, and when once the shot has left the muzzle of the gun, the gun can no longer influence it after that, its range and penetration must depend upon the shape and weight and hardness of the projectile. Now, with this 120-pounder shunt gun firing a 98 pound shot with 24½ pounds of powder, which is exactly one-fourth of the weight, the initial velocity, measured by Navez's electric apparatus, was 1,690 feet; the initial velocity of a shot from a 68-pounder is less than that.

Captain FISHBOURNE: Will you allow me to explain? Captain Heath is talking of a different thing altogether. He is talking of a gun that was altered for a particular experiment. The quotation that I made, had reference to the original 120-pounder with its original small charge, and which was given to the country as a complete gun, until the question was raised by myself eighteen months ago; and then a new series of experiments were made; the shot was shortened, and the charge was increased nearly one-half. I am speaking now of the shunt-gun.

Captain HEATH: It has never been in the service; there was only one experimental 120-pounder shunt-gun made. We are speaking of the same gun and the same experiment.

Captain FISHBOURNE: That was a subsequent experiment altogether; there was a shunt-gun in the service before that one.

Captain HEATH: They are all experimental guns; there is no shunt-gun in the service.

Captain FISHBOURNE: I mean for the service. It was received into the Arsenal, and accepted as a Government gun, and paid for.

Captain HEATH: There is only one of them; there has never been than more one that I am aware of.

Captain FISHBOURNE (pointing to the diagram): What are all these different guns, then?

Captain HEATH: I am speaking of the one which you say was fired with a 98-pound shot, and 24½ lbs. of powder.

Captain FISHBOURNE: That was not the one alluded to by the authority from whom I quoted those remarks, nor was it tried with that charge and with that shot until after I read my first paper here. We are speaking of a different thing altogether.

Captain HEATH: Well; the actual velocity of the shunt gun with a charge of one-fourth the weight of the shot, was 1,690 feet, against the 68-pounder giving a velocity, I think, of 1,590 feet. Then, again, the same thing may be shown in various cases. Here is the 12-pounder Armstrong with a 2 lb. charge, and an 8 lb. shell; it had an initial velocity of 1,746 feet. Here is the 110-pounder gun, with 25 lbs. of powder and 100 lb. shot—that is one-fourth the weight of the shot—and its initial velocity was 1,591 feet, which is again slightly in excess of the 68-pounder. I think I need not quote any more examples. These figures are valuable, and should be remembered, for it has been the custom to compare smooth-bores with rifled-guns, without taking into consideration the relative weight of shot and the relative charge of powder. I think no such comparison is fair. You should

compare guns of the same weight, because in taking a given ship you must consider its scantling, and what weight of metal it will bear, and you must, I think, for a fair comparison, have the same weight of powder and the same weight of shot.

Captain FISHBOURNE: And the same tension on the gun.

Captain HEATH: No comparison of that nature has yet been made. One will be made soon. There is a 100-pounder smooth-bore at Portsmouth, and a seven-inch 100-pounder of the same weight nearly completed. When these have been tested, you will have a better means of comparison.

Captain FISHBOURNE: A strong gun against a weak gun.

Captain HEATH: Both of the same weight.

Captain FISHBOURNE: But not of the same make; the weak gun will not bear the same charge as the strong gun.

Captain HEATH: There is another fact; the 110-pounder Armstrong gun, with its initial velocity of 1,125 feet, as proved by experiment, has a remaining velocity at 1,000 yards of 970 feet; the 68-pounder, with its 16 lb. charge, has an initial velocity of 1,579 feet; and its remaining velocity at 1,000 yards is 975 feet. That I must tell you is by calculation and not by experiment; but it is believed that the calculation is quite close enough for practical purposes. I thought perhaps these figures might be of use in the future discussion of the question, as I shall not be here myself to-morrow night.

Captain FISHBOURNE: Captain Heath has not objected to a single fact brought forward by me, on the contrary, what he has said has been to confirm my statements. Thus he said I was killing on paper that which was already dead, in fact, enumerating some points of detail which had been changed or abandoned. No doubt the principle of the gun and projectile was wrong, and the erroneous results have forced the authorities to throw off, reject, and try to amend many of the details.

The country has been kept from having a gun and projectile upon a correct principle, because those who ruled in these matters allowed Sir William Armstrong to be continually mending his hand at any cost to the country, hoping that, per adventure, he might some day get into the right groove.

The numerous changes and the palpable necessity for them would have conveyed to practical minds that there was no room for any such hope, and that any effectual change must be a change of principle.

As to high velocities they were not thought of till I read my paper (1862), indeed, they were said not to be necessary. Sir William said, in his evidence, that 1,200 feet per second was the proper velocity. No doubt the correctness arose from the fact that he could not obtain higher with safety and accuracy, of which he was well aware; not so those who undertook to obtain higher velocities, and who thereby have destroyed his guns. This is one of the points on which Sir William and his admirers have been at issue, four and twenty hours would scarce suffice to tell of their contradictions, which, if set in opposition, would, like the Kilkenny cats, destroy each other leaving only the tail.

And as for Captain Heath saying we shall have a fair experiment at Portsmouth, I reply it will not be a fair experiment, a weak smooth-bore gun that no one will undertake the responsibility of firing a full charge from, with only a round ball is to be contrasted with a strong rifled gun, each carrying charges of one-fourth the weight of their respective shot; unless there is equal tension on the guns, there will be no fairness in the comparison.

Admiral HALSTED: They will fire both one and the other, under circumstances which will be no true representation of any armour-plated ship whatever.

Adjourned Discussion.

Tuesday, February 2nd, 1864.

Lieutenant-Colonel T. ST. LEGER ALCOCK, in the Chair.

Commander W. DAWSON, R.N.: I wish to say a few words as a seaman gunner, and I am sure, if any other seamen gunners were present last night, they must, in common with myself, have learnt a great deal of the theory of gunnery, from the paper which was then read, and were, no doubt, equally pleased with the very clear illustration that we had of many of those theories, with which practical men are not so well acquainted as they ought to be. When I came into the Lecture Hall last night, I confess that I was almost an advocate or partisan of what I might call the "multi-system" principle. Believing that every system had something good in it, I came here expecting to hear something of each particular system. I expected to have heard, for instance, of the Whitworth system, of which elsewhere we have heard a great deal, but no officer that I have ever met with, has ever seen the gun fired: therefore, I should have liked to hear something more of it, more particularly as there is a Committee now sitting, which has been sitting for the last twelve months upon the subject, and has not yet come to any decision. Then there is the Bashley Britten system, which I have heard a great deal spoken of, and I should have liked to hear something of it. I confess myself very ignorant respecting it. I know its principle, but I am very ignorant as to how far it has been successfully tried. There are several other systems of which I should also have liked to have heard something. It appeared to me, that Captain Fishbourne confined himself rather to one system, the multigroove system, and he handled it so ably, that I must confess, instead of being a partisan of the multi-system principle, I feel very much inclined to be a partisan of the multigroove system, more particularly from the author's own statement. I rather think he began by trying to prove too much; he began by an assertion, that the multigroove system was acknowledged by everybody to be an effete system, and then proceeded to bring forward facts, which, I must confess, according to my experience, were somewhat exaggerated, and, in many cases, I should say misapplied, by which he proved, or sought to prove, that the first assertion that he made was a universally received one. For my own part, speaking as a seaman-gunner, who, in the course of service, has had the superintendence of the firing of some three or four thousand of these multigroove system projectiles, a great number of them in circumstances of motion, and very active lively motion,—some of them in a frigate, but the majority of them in a lively gunboat, and under circumstances of weather and motion, which, I think, form a very fair sea trial, the facts or conclusions that I arrived at, from what I observed, were very different. I must confess I saw very little of those horrible catastrophes which almost made one's hair stand on end last night; in fact, I think if I had known that it was such an awful gun as it is, I question very much whether, having a wife and a small family, I should have been doing right to trust myself behind the fire of such guns. But, happily, I was quite ignorant of these illustrations, and during the

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experience of those three or four thousand rounds that I have seen fired, I must confess I never saw an accident of any importance. The accidents that did occur, I will refer to by and by. As to the gun itself, I am very well satisfied with the accuracy of the bore. There are two parts, I think, in the firing of a gun to be looked to; first, with reference to the internal part of the bore; secondly with reference to the sight. I should have liked to hear Captain Fishbourne go a little farther into the question of the sighting. He gave us some illustration with reference to the firing with motion—a very apt illustration, which I was very glad to receive, but I should have liked him to go a little more into the other question. With your permission, Mr. Chairman, I will presently say a few words on that subject. I will speak first with reference to the accuracy, and I will only state exactly what I have myself seen, giving not so much opinions as facts—facts which are reliable, and which have been seen by myself and other officers. With reference to the accuracy of these guns; this unfortunate one that got its muzzle blown off, or rather the fellow of it—not, I dare say, that identical one—was at Shoeburyness about four or five years ago, when the Armstrong gun first came out, and I was sent, as one of the naval officers to be instructed in the practice of this gun. One day we were practising at a target only 500 yards distance: the size of target at Shoeburyness is about 12 feet square painted black, and having a central line of white paint up and down, vertical and horizontal, and a bull's eye in the centre. On this particular occasion it was necessary to fire a concussion fuze shell into the central part of the target, which was strengthened behind in order to shew the action of the concussion fuze, the remainder of the target being of slight manufacture. In order to ascertain the centre, the instructor thought it was necessary to take a trial shot, and a trial shot was taken. Of course, had the elevation been exactly correct, and the shot had gone true, it must have gone into the bull's eye. It did not do so, but went about 30 inches below it. Making a certain allowance on the sight for that 30 inches, which speaking roughly from memory was about 6′, we put in another shot, the instructor was so satisfied that with those 6′ the shot would have struck the bull's eye, that he wanted to put in a shell, but the naval officers wished to make a complete bull's eye, so that to gratify them, one more shot was tried. To our astonishment, it came up to the horizontal line, but yet about 30 inches to the right of the mark. Our faith in this sight was then very much lessened. But we had a very intelligent captain of the gun on that occasion—a very intelligent gunner of the navy. He ran back to the sight, looked at it, and to his surprise found that his deflecting sight had been touched, which moved the deflexion about 5′ or 6′ to one side, thereby entirely accounting for the deflexion of the shot to the right. So satisfied were we with the result, that we now put in the shell, which went through the bull's eye, and of course we saw no more of it. This occurred to myself, and I relate it as being one of the many thousand shots I have seen fired, to show what the accuracy of the gun is from a steady platform. But I will give another instance, with reference to the 40-pounder, one of the guns that have not been abused. The Lords of the Admiralty came to Devonport at the time of the introduction of the 40-pounders into the naval service. We had not at that time one embarked, and I was commissioned to go to the gun-wharf and bring away a 40-pounder. I was instructed to embark that 40-pounder and anchor to a small anchor, in order to fire it at the Shag rock, which was at a distance of nearly 2,400 yards. I fired the first shot at it; I judged my distance and my sight so accurately—it was merely an accident I suppose—that it struck the rock the first time. I was perfectly satisfied, that if the sight did that once, it would do it fifty or a hundred times. I had such faith in the gun, for land purposes, that I went into harbour, and reported that I was ready to shew their Lordships this gun. I took their Lordships out, and in the passage out, I must say, I heard a great deal condemnatory of the gun. When they arrived out, they were very much astonished. The range fouled a little, so that we could not fire at the Shag rock, and we tried at a rock a little to the left. The first shot fell close to this rock; that, of course, I expected, but they were very much astonished. The range cleared, and we aimed a second shot at the Shag rock and struck it; we then aimed a third shot, and again struck the Shag rock, shewing that it was no accident. A little accident did occur, which, I must confess, was not known to any person present but myself. It occurred

to one of the sights—we must confess faults as we go along, but these are only little faults of detail—there are faults of detail, particularly in the matter of sights. The quoin flew out and struck the side sight, and bent it, but no one was aware of the fact. Fortunately for the credit of the gun, the range fouled, and no one knew that the sight had been injured. That does not affect the correctness of the sight, or the truth or accuracy of the gun. You will remember that I have been speaking of the gun on a fixed platform. When we come to a movable platform, we enter on quite a different subject; that is to say, a sighting which will direct a straight and true bore (as I believe the Armstrong gun to be) correctly to the mark from a fixed platform, will frequently fail to do so when fired from a movable platform. I am not going into the question of building ships, which involves the principle of a good platform; but I wish to put on record opinions I have formed from experience, shewing what those opinions were formed from, as to the correct object to be aimed at in sighting guns. Now with regard to the trunnion-sight of these new rifled-guns, that we can speak of as being admitted into the navy, and so far the best rifled-guns that we know of adopted in the world; the distance of the trunnion sight from the base sight is so small, that any little visual error in the gunner who directs the gun is multiplied. This does not appear on shore, because you go close up to the gun, lay it correctly, take your time about it, then walk away from the gun in a very leisurely way, and direct somebody to fire it. That is not the case afloat. You must stand to the extent of the trigger line, and the very fact of doing that, it may not be known to all present, but I suppose it is known to all seamen-gunners, causes a visual error, the error varying in amount according to the state of the atmosphere, and according to the fact of the gun being covered or uncovered, also according to the state and condition of the sights. This visual error, although variable in regard to quantity, is still constant. It varies from about $\frac{1}{16}$th to $\frac{1}{4}$th of a degree, depending upon these conditions. But in addition to that, firing afloat, particularly with the quick, lively motion of a gunboat, in which I have had my principal experience of this matter, is exactly like firing at a bird or a flying object. There will, therefore, be a certain amount of error in the eye. The eye will be a little above the tangent-sight, it may be a quarter of an inch or a half an inch. Now a little reasoning will show you that if the error amounts, say to $\frac{1}{4}$th of an inch above the tangent-sight, the error of the short radius from the tangent-sight to the trunnion-sight is in many cases, in that particular gun for instance, more than double what it would be if you had a dispart on the muzzle. Of course we know that there are difficulties and objections to disparts on the muzzle; nevertheless, I think, if the thing was properly sifted, and we concluded that the sights were badly placed, we should make an effort, if not to place disparts on the muzzle, at least to place them further out than at present. I see no reason, for instance, in the present broadside guns, smooth-bores, why our dispart should not be placed a foot and a half farther out. It would not interfere with the portsill, which is the only thing you have to consider. In our small gunboats, where there is a very lively motion, it is really essential that there should be a muzzle-dispart. Take the case of a boat's gun, not to weary you with too many figures, suppose the present short 20-pounder, as I think they call it now-a-days, was fired with a visual error of half an inch, which is not very much, not more than you usually expect. Now, that half inch, with the very short distance from the sight to the trunnion, would make an error of 277 yards; speaking roughly, we will say 300 yards. But if the sight, instead of being on the trunnion, was on the muzzle, the error would only be about a third, about 109 yards. That which first led my mind into this channel was a comparison between the 68-pounder, and the 40-pounder, and the 100-pounder. These guns were, as I have said before, fired simultaneously, that is, on the same day, and in the same circumstances of weather and motion, and it was generally observed that if we had a signal man always at a right angle to the range—and for all sea practice that ought to be the case, particularly if you want to make correct observations—it was observed that, at a distance of 2,000 yards, the 68-pounder, that splendid gun (one of the best guns, I think, we have had of that size) using the muzzle-dispart, made more accurate practice than the 100-pounder, or even than the 40-pounder; and it is essential that, with any rifled gun, firing elongated shot, the first dropping of the shot should be accurate,

that it should in fact fall at the object and strike the object, because in circumstances of motion at sea there is always of course a certain amount of swell, and then elongated shot, I believe, whether Armstrong's, or Whitworth's, or Scott's, or whosesoever they are, all *ricochet*, I believe, not in a straight line, but, as far as my experience goes, to the right. That of course depends upon the twist given, and, according to the twist generally given to English guns, they *ricochet* to the right at a considerable angle, as much as 45°, so that we do not get the advantage of *ricochet* in elongated shot. It is, therefore, very necessary that you should pay great attention to the rifle sights. Now great attention has been paid to the sights, but, unfortunately, the attention has been paid in the wrong direction. You may smile, but I am not here as a partisan of any particular gun, but merely to point out, what, according to my experience, are the faults of different guns with which I am acquainted. I merely speak from what I have observed, not from any theories. I say that the sights of the Armstrong guns have been graduated to minutes. Those who have used the gun on shore with the close sight—I do not know whether it is in existence now, but it was a beautiful little sight —must know the value of raising the sight to minutes, because you can lay the gun with such extreme accuracy that the minute alteration in the sight makes a corresponding alteration in the range. At a distance of 3,000 yards, I believe, the corresponding alteration is some 5, or 6, or 7 yards. If the gun is correctly laid, the bore of the gun obeys the sights; the difficulty is to get the sight in the right direction. Now this nice graduation, for sea purposes, is of no avail, because you cannot use the close sight at the end of the trigger line. I have shown that a visual error exists by standing at the end of the trigger line, and that this error is increased by the motion of the ship, that is, the liability to error of the captain of the gun not having his eye close down to the points of sight. Under these circumstances, I maintain that it would be very preferable for ordinary sea purposes that there should be none of that minute graduation, but if our tangent-sights were graduated to 5′ it would be quite near enough. Instead of giving attention, then, to this minute division of the tangent scale, I think it would be much preferable if attention was directed to placing the dispart farther out. Now, comparing the 68-pounder and the 100-pounder together in the case of firing over 2,000 yards, the muzzle-dispart in that case is always used for the 68-pounder, as a matter of course. In that case the error of half an inch in the eye of the captain of the gun would make an error with the 68-pounder of 50 yards, but as the 100-pounder and 40-pounder, which are the two guns I compare it with, have not a muzzle dispart, but have only a trunnion-sight, the error with them would be 200 yards, that is to say, about four times as much. So much with reference to the matter of sighting. I think it is such an important matter that it would be well to draw attention to it, even with regard to our smooth-bore guns. There is, as I said, no reason why in our boat's guns there should not be a muzzle-dispart, as there was of old, and with all our guns mounted *en barbette*, as in our gunboats and flush-deck vessels, if the chase guns had a muzzle-dispart, of a very solid nature, that could be shipped and unshipped, or fixed and unfixed on special occasions, if it is not desirable to have it perfectly fixed, I think it might be rendered more feasible by reducing the height of the tangent-box, and in the guns with side sights, I think it would be much more easy to accomplish, and it is a great pity that more attention has not been drawn to it. Having pointed out what I consider the defects which escaped the notice of Captain Fishbourne, I might allude to the small initial velocity, which will in some measure account for the difference of accuracy, with motion, between the Armstrong gun and the smooth-bore. I am not inclined to give that error so much importance as I give to the sights. I believe that the sights will account more for this error, than the small difference in the time of flight along the bore, between the smooth-bore and the Armstrong. As I said before, my experience of the Armstrong has not been so unfavourable as Captain Fishbourne's, except in regard to those one or two little defects, which are all capable of correction, and I have not seen any accidents, except those which I will name. Out of these 4,000 rounds, it would not be surprising if a few accidents did occur, and I do not think a few accidents, unless they are of very great importance, should condemn a gun altogether. I remember being told that a frigate went into Sebastopol with smooth-bore guns, before the Armstrong

was heard of, and that, on her first broadside, one of her guns burst on the main deck. Now that one accident does not condemn the smooth-bores, or condemn cast-iron guns. On two occasions, in firing small Armstrong guns, the vent-piece flew out, in consequence of the breech-screw not being screwed up, from the carlessness of the people using it. Those were the only two cases of the kind, out of the many thousands of shot that were fired. No accident to life or limb occurred; no one was hurt, and nothing of any consequence happened. We lost, I believe, the vent-pieces altogether, but we had new ones, and went on with the firing. Nobody was frightened with the gun afterwards. It evidently arose from want of training. Since, then, a considerable improvement has been made in the shape of the vent-piece, by which its liability to fly out is considerably decreased. Another error which I observed in the younger days of the gun, about three or four years ago, I believe has been repaired in a great measure. It was that sometimes the lead stripped off. That occurred so seldom, that, having fired as many, I should say, as a thousand rounds, I was convinced in my own mind, that the lead never did strip, but subsequent experience shewed me that it would sometimes do so. I suppose that it occurred with older shot that had been long in store, or something of that kind, but I believe that defect has been in a great measure obviated. Of one thing I felt perfectly certain, from the little experience I have had of other guns, that Sir William Armstrong's gun has fulfilled, as far as the bore of the gun could do, all necessary accuracy. The bore of the gun is extremely accurate, but all elongated projectiles have a certain error with reference to sea practice, they will not *ricochet* in the right direction; unfortunately they will *ricochet* to the right, so that you cannot get the benefit of the *ricochet*—an invaluable quality of the smooth-bore guns.

Naval officers, hitherto, have paid little attention to ascertaining distance. They have looked upon it as so subordinate a matter, that, in practice, we seldom know what is the distance of an object at sea. We know roughly within two or three hundred yards up to a certain distance, but beyond, say 2,000 yards, I really do not know how you are to ascertain the distance; so that the advantage of the long range, whether with the Armstrong gun, or any other gun, is, I think, all a myth. I do not believe in it. What we want is a good smashing gun for moderate distances, and whether that good practical gun comes from Armstrong, or Bashley Britten, or Captain Scott, it does not matter to naval officers. For my own part, I should be glad to see my gallant friend, Captain Scott, beat every other inventor out of the field, and all I hope is, that if he does, somebody else will come and beat him out of the field.

Mr. Lancaster: The very able paper with which Captain Fishbourne has favoured the meeting, according to the impression I have received of it, appeared to deal with the two principal subject-matters; first, an inquiry into the material of which a gun could be made, and observations on it; and, secondly, the method of rifling to be employed. To those topics, with your permission Mr. Chairman, I will confine my attention. Much discussion, not only in this Institution but elsewhere, has arisen on the subject of the material of which guns should be composed, and in what method they shall be constructed. It is needless to recapitulate the very able arguments adduced on both sides, but the drawings that have been exhibited to us would seem to shew that gradual experience is determining what should and what should not be the method of constructing a gun. If experience shews, by irrefragible evidence, that in the construction of a particular gun, a particular strain has been omitted to be calculated for, and consequently has not been provided against, you have a step gained in the right direction. Now, I do not think it is any longer matter of doubt that we may describe the built-up gun, as being longitudinally weak, the longitudinal strength of a built-up gun being represented by a cross section of the interior tubes, plus the friction of the exterior tubes. In comparison with a gun whose cross section should be homogeneous and solid, I think it must be held as proved, that a gun so built up must be intrinsically weaker, whatever the other condition of the gun may be. I fear that in the question of the material of which the gun has been composed, sufficient attention has not hitherto been directed to one very important question. Having read with, I believe, the most earnest attention, all the scientific

brochures that have appeared on the construction of artillery, I have never yet seen a proper appreciation of the time in which the work is done. Now, unless we estimate that important element, we can never arrive at the material which should be employed. With your permission, I will shew you a few figures to demonstrate this proposition. I am not now relating any mere opinion of my own, but am referring to facts that have come before my notice, in the services in which I have been engaged in Government matters at the Woolwich Arsenal. Having been called upon by the Government to strengthen some cast-iron guns, and it being a question, in my own mind, as to the proper material which should be employed in the formation of the outer coils, no matter of what form they might be, to strengthen the cast-iron artillery, I had a conversation with the then Assistant-Superintendent of the Royal Arsenal at Woolwich, Mr. Anderson. Various kinds of iron were shewn me, as being very excellent, as employed for outer coils of the Armstrong gun, and possessing the enormous strength of 26 tons to the square inch. I beg you, gentlemen, as scientific men, to remember this, that the instrument by which this iron was tried, was what is termed the tensile machine at Woolwich Arsenal, which exerts its power very slowly, taking, sometimes minutes in the operation. Now, mark the consequence. If this very quality which rendered that iron so very highly resisting to a slow pressure, be used in a gun, for instance, where the pressure is exerted simultaneously, the very qualities that give it resisting power to the slow pressure, are the very worst that you can employ in the gun. Now, what is the consequence here? We have a pressure of 26 tons; this coil was a trapezoid of about 4 inches; we took that bar and nicked it all round with a cold chisel, put it on the anvil, and called a hammerer out of the forge, and told him to give it a strong blow with a 25lb. sledge, Now, how many blows do you think that cube of four inches stood before it broke? You will be surprised when I tell you that it broke at the first blow, like so much cast-iron. Now, we took some wrought iron which represented 19 tons, Welch iron made by Brown and Hughes; we nicked it the same depth as the 26 ton iron; we put it over the anvil, and called in relays of hammerers. We found that it stood 282 blows, and then it did not break, but was merely bent round. This shews the extreme value of testing any iron by percussion, and the extreme danger of relying solely upon a testing machine, and saying that that is the best material for a gun which can be subjected to it. Now, let me give you a further illustration. When these bars were made into a coil and put upon the Armstrong gun, I saw many of them taken off the guns, and put under a steam-hammer. The blow was not given by the steam-hammer as a fair blow, but merely a little tap, and the coil broke into fragments like glass. Does this not explain that sometimes very valuable experiments may result in many failures that are not fairly attributable to the system, by an injudicious choice of material not adapted for the particular purpose? We come also to another particular point, which is this: if you have a bar of iron or a bar of steel, and nick it round in this way, you arrive at a very peculiar proposition. The bar of iron nicked round will stand a vast number of blows; the bar of steel, or a bar of iron wrought up into the condition of steel, breaks immediately, and the value of the proposition, carried out in guns, is this: if you nick a gun by a groove inside, which will put it into the same condition as a bar of steel, and if you have a hard material, like iron very highly wrought, or some kind of steel, you very materially weaken the interior of your gun. Now we come to the question of grooving:—This has been a question very much debated, and many gentlemen of eminent talent have joined in the discussion, and with much propriety have advocated their peculiar views. Time, alone, will shew whether those views are correct or not. But a very little will solve the question beyond all cavil, and it may be done in this way: with every kind of groove, no matter what that groove may be, and when a shot is used that has hard metal projections upon it, whether they be bronze, or cast or wrought iron, if you have a windage between the ball and the bore, the whole bearing of the projectile must come on to the edge of the groove, no matter what the form may be. You have 600lbs. weight in a projectile like that, and a windage say, of ·05 or ·06. If you put 50lbs. or 60lbs. of powder behind it, you will have an initial velocity of twelve or fourteen hundred feet. Well, 600lbs. at an initial velocity of 1,200 feet per second, will, in a few rounds, knock the edges of the groove into a cocked hat.

The proof is to be found at Woolwich Arsenal in some competition guns that were fired last year. You see here the seat of the shot, the driving edge of the groove is cut out into a curve; the button in the shot is shunted over to the other side of the groove; there is the re-entering angle, and there you see where the gun burst into fragments. No matter whether the button is of bronze or of zinc, the same result is produced. I had the pleasure of seeing some experiments with that splendid gun, made by Messrs. Krupp for the Russian Government, when I was at St. Petersburgh a little while ago. Here the grooves are very analogous, except that there are two rows of buttons and ten grooves. The gun burst in 50 rounds; prior to bursting, precisely the same effect was produced upon the steel groove with the zinc button on the shell. That is the effect of setting a mass of metal, weighing five or six hundred pounds, in motion at a velocity of 1,200 or 1,400 feet a second; you are certain to destroy the gun; nothing can prevent it if grooved in the ordinary method of angles and edges, having projections on the shot to fit into the grooves.

Mr. Barrass: In continuing the discussion upon Captain Fishbourne's admirable paper, I feel some hesitation in venturing to make any remarks upon such a subject and in such an assembly, but having been interested in observing some ship guns in the batteries of Sebastapol which I found to be on measurement of greater calibre than our then greatest gun, and they were of excellent workmanship, and were also free from mouldings and other abrupt variations of dimensions which are known to be so dangerous to cast-iron objects, and having been disappointed with the results hitherto shown by the wrought-iron guns, I cannot but acknowledge feeling some interest in the subject before the meeting, and that in the hands the subject is now in, something may be done to advance the state of British gunnery. Ten years ago the Russians seemed to be in advance of us, as I believe the Americans are now from the improvements in the systematic preparation of the metal, and the casting of guns with cores and cooling from the inside on the plan of Lieutenant Rodman, and considering the efficient manner in which steel is now manufactured in large masses, and its application to guns on the Continent by Krupp, it is to be feared that the next war will find us as we were, behind even Russia in the application of science to implements of war.

In such an inquiry as the present, as to the best material for the manufacture of guns, it seems to me desirable to endeavour to establish a first principle upon which to base a comparative estimate of the enduring powers of those metals which are eligible for the purpose of making guns.

The first question then that arises will be, what is, or what are the forces that obtain in a gun at the instant of discharge, and what their amount and to what extent, the question of the limited time in which these forces act, may influence and modify the action of those forces, and their consequent result upon the gun.

With respect to the nature of the forces thrown on the gun by the explosion of the powder, it has generally been considered to be one of tension only, but a consideration of the facts of the great amount of work that has been got out of cast-iron guns, and the small amount of work that has hitherto been got out of wrought-iron guns,—making all due allowances for a comparatively new manufacture,—it appears to me, that, seeing a material possessing a high tensile power like wrought-iron, giving practical results, in nothing like the ratio of its tensile power, it is not upon tensile power only that we are to base a comparative estimate of the eligibility of metals for the purpose of making guns, and if the tensile power of metals be not a true criterion for the purpose, the transverse strength will always hold a definite ratio to the tensile power, and therefore the transverse strength can only hold good as a criterion when there is no great disparity between the tensile and compressive powers of the metal; and I think a little reflection will show that the transverse strength of a metal is not a true measure of the eligibility of a metal for a gun, inasmuch as that the gun in firing, is not submitted to the mechanism of the transverse strain, the strain is a direct one, and is either tensive, compressive, or the two combined, and it is to the latter action I am inclined to refer the forces at work in a gun at the moment of discharge. A force requires time for its transmission, and different metals and materials will require more or less time for that

transmission, according to the direct resistance to tension and compression, and if we conceive that in the case of a gun, the tensile force has not had time to pass through the whole thickness of the gun, then there will be a variable tension throughout the thickness which the force has had time to pass, because those fibres which have been longest under tension will be stretched the most, and they will be those of course nearest to the chase; and in like manner if the force, on passing through the thickness, is enlarging an annulus at the radius at which it has arrived, that enlargement will induce an annulus of maximum compression immediately beyond it, and this compressive strain again, like the tensive, being a variable one, through the thickness, it has had time to pass, and is a maximum at the point immediately beyond the annulus of tension, and a minimum at that point where it has not reached, and thus the gun may be considered to be in a state of both compression and tension according to the time of being submitted to the strain, and according to its willingness or unwillingness to have the strains passed through it. If there were plenty of time for the due transmission of the tensile strain as in a hydrostatic proof, then the whole thickness of the gun would, no doubt, be in tension, but if there is not time for this due transmission of strain, (and since the exterior annulus of the gun may not have received any strain at all, and we know that the annulus next to the bore has received a maximum of strain, and consequently of enlargement,) then a mixed strain of tension and compression will be the result, and the resistance of a gun to the explosion of gunpowder will be as the mean tensive and compressive powers of the metal; and it appears to me that it is to such a consideration that we are to attribute the enduring powers of cast-iron guns. A material having a low ratio of tensile power, but that tensile power not being permitted to act by the greater compressive power beyond it, and its consequent unwillingness to pass the strain through the whole thickness of the gun, and permit it all to go into tension. That the question of time, therefore, should be duly admitted in an investigation like the present seems to me clear enough. It was while proving by hydrostatic pressure some wrought-iron girders, and observing, even with the naked eye, the time that was requisite for the forces of compression and tension to pass out of the girder after the load was completely removed, a result I had never observed with cast-iron girders, and no doubt due to the high compressive power of cast-iron, forming a more rigid heel to bring the girder back more quickly to its original position again. In the experiments in the United States also it was found that a weight applied for a short time only, produced no permanent deflection on a bar rested on supports and loaded in the middle, but when the weight was left on all night, an appreciable and considerable permanent set was the result, showing the importance of the influence of time in such considerations. The enlargement of the bore is always most between the charge and the shot, indicating that the maximum disruptive force is just before the inertia of the shot has been overcome, and also where the gun is most heated and acted upon by the incandescent gases, and the proof also that there is a strain of compression as well as of tension by the fissures which often exhibit themselves about this part of the gun, whilst the exterior of the gun has preserved its form and dimensions.

Estimating on this hypothesis, the comparative values of the several metals as a material for the manufacture of guns, we have for the ultimate strength of ordinary cast-iron:—

In compression	92,000 lb.	per square inch.
In tension	19,000 lb.	„ „
	111,000	
Giving a mean of	55,500	

And according to the late Woolwich experiments:—

In compression	91,061 lb.	per square inch.
In tension	23,257 lb.	„ „
	114,318	
Giving a mean of	57,159	

Ordinary wrought iron:—

In compression	38,000lbs. per square inch
In tension	60,000lbs. „ „
	98,000
Giving a mean of......	49,000

This, however, is ordinary merchant bar iron. If we had the mean of iron from guns, we should probably find it about the same as cast-iron, but, unfortunately, I have no data. All experiments with wrought-iron from guns having been confined to the tensile strength only. While of the wrought-iron gun forged at the Gospel Oak Iron Works, and which burst at the first discharge, we have no data at all. For steel we have a mean of 120,000lbs; for its resistance to compression and tension are about equal; and this points to it as being the most eligible metal for the manufacture of guns, and as promising a durability double that of wrought-iron for such a purpose. I am not enabled to give the mean of the cast-iron which is used in America, on their improved systems of preparing the metal, and casting with a core, but from the high ratio of the transverse strength, and which was the test to which the bars were submitted, it would appear from the high ratio and the greater durability of the guns that in these processes the tensile strength of the iron is increased without materially impairing the compressile. The resistance to tension by these processes having been increased by 60 per cent., and the durability of the guns from 15 to 30 per cent. The proof bars of the same metal as that from which the guns were cast, I might observe, always bore a higher ratio of transverse strength, than bars cut from the gun after being cast; but this is always the behaviour of cast-iron, the smallest mass arranging itself in closer and more coherent crystals; but this fact remains indisputable, that by submitting the metal to repeated fusions, and keeping it each time for a period in a state of fusion, it is, in a certain measure, decarbonised and purified, and so having its tensile strength increased 60 per cent., as was the case; why the guns did not follow the same ratio of increase of durability as the increase of tensile strength of the metal, the suggestion which I am now making will probably supply the explanation, viz., that the resistance of a gun is not as its tensile strength only, but as its tensile and compressile jointly, and that in increasing the tensile strength of the cast-iron by the process of decarbonisation which I have quoted, the metal approached closer to wrought-iron in its nature, and that as its tensile strength was increased, its compressile strength was decreased, but not in the same ratio, a maximum gain of 30 per cent. being the final result in the durability of the guns, though the tensile strength of the iron was increased 60 per cent., or double that of the durability of the gun.

Continuing the comparison to Bessemer's steel, as introduced by Captain Fishbourne last night, its resistance to compression is 103,255 per square inch, and to tension 111,460 per square inch, giving a total of 214,715, and a mean of 107,357lbs. per square inch, and arranging these results together, we have—

For ordinary cast-iron	55,500
Cast-iron at Woolwich	57,159
Merchant bar for wrought-iron	49,000
Cast-steel	120,000
Bessemer's steel..................	107,357

From which it would follow, that the durability of a cast-steel gun would be double that of a wrought-iron gun. To complete the table it would require us to have the mean from the United States guns of cast-iron, and from our own guns of wrought-iron; and then we would be able to make a complete comparison, and test its value by the results of actual experience; but as far as it can be carried at present, it seems so coincident with actual experience, that I venture to lay it before you, for it has been observed by the officers of the United States, that the densities of the metals were not in the same relation as the tensile strength; and when the mechanical properties of some metals are considered, it would lead us to guard against assuming one property from a metal in the relation of another, and similarly to guard us against assuming the strength of a gun to be in the relation of the transverse strength of

the metal, seeing that the metal in the gun is not submitted to the mechanism of the transverse strain when firing, and also against assuming that the strength of the gun is in the relation of the tensile strength of the metal, if the strain in the gun is *not* wholly a tensile one, which a comparison of the relative durabilities of cast-iron and wrought-iron guns leads one to suspect is the case.

With a view to measuring the forces in a gun during the explosion of the powder, I have thought a series of small pistons, fitting holes drilled from the exterior to the chase of the gun, and at intervals from the chamber to near the muzzle, similarly to the measure pursued by Admiral Dahlgren, might be of considerable service in determining the forces in a gun when discharging, only instead of measuring a relative force as in Admiral Dahlgren's plan, measuring the absolute force by having an index to each piston, the exterior end of the pistons acting on springs like a spring-balance, and which have previously been adjusted. Such instruments could be clamped on the gun, in a manner to compensate for the weakening of the gun by the piston-holes, and every strain due to the several conditions of charging, shotting, windage, and lead-coating the projectiles, could then be ascertained, for considering that ¾oz. of powder when perfectly inclosed in a shell, will exercise a disruptive energy equal to 72 tons, and that when the shot sticks in the gun (as Lancaster's egg-shaped shot did in the Crimea, from the absence of the shot having any means of preserving its longest axis in parallelism with the axis of the gun) bursting is the result. Then it follows that much of the durability of the gun will depend upon the shot being free to leave it on the explosion of the powder, so as to limit the time during which the gun is under strain, and prevent the undue accumulation of force from the incandescent powder. Such an instrument, or series of instruments, would register the variable pressures in the gun from the chamber to the muzzle, and for all the several conditions of charging and loading; for I have an impression that the disruptive force in the gun would not be that due to the charge alone, but mainly due to the shotting, or to a moderate freedom, without windage of the shot, to leave the gun, instead of sticking and compelling the gases to accumulate force, to the injury or probable bursting of the gun.

The two strains of tension and compression in the gun during explosion, being variable in amount, and the tension a maximum at the chase, it would follow that it is a mere question of time when the gun bursts, that metal which offers the greatest mean resistance, offering the least annulus to maximum strain, and making the most endurable gun; and cast steel, in its natural state, seems to offer those desiderata, which are demanded of a good and endurable gun, and to be preferred to any system, however ingenious, of built-up, hooped, bushed, compound, or welded wrought-iron guns.

Touching one point that was raised in discussion last night, Captain Fishbourne's argument, or his mode of illustrating it, was questioned, the observations being associated with the law of the expansion or dilatation of gases. Now, if I understand Captain Fishbourne's argument, he wishes to illustrate a question based upon mechanical considerations only, and represents by the figures in the diagrams the increments of strain that may be added to the gun by rifling, bad rifling, or other unnecessary obstructions, and that, whatever the amount of the obstruction may be, the initial velocity of the shot will be reduced, and the strain upon the gun increased in the same proportion. Now, this to my mind is a very lucid way of putting the question, and shows, that whatever amount of force may be subtracted from the shot, is necessarily, or rather unnecessarily thrown upon the gun; and being a mechanical consideration, it is wholly independent of any physical laws either of dilation or anything else; though it appears to me, that even admitting the law of the expansion of gases, Captain Fishbourne's illustration is as near the mark as anything that could be adopted for illustration, seeing that to accommodate the lead-coated projectiles, a slow-burning powder has been especially made, for them to fulfil both physically and mechanically, that very condition which Captain Fishbourne's illustrations represent. If the gas was all evolved at once, then the law of the expansion of gases would obtain; but there are several conditions which make the application of this law to the question doubtful, the powder may be quick or slow burning, and of the force of the gas, much will depend upon the freedom of the shot to get out of the

gun as my previous observations have stated. That appears to me so much to the point, and observations mentioning the law of expansion of gases tending to confuse the argument, that I have thought it desirable to name it, though I have no doubt I might have left it in more able—Captain Fishbourne's—hands.

Captain JASPER H. SELWYN, R.N.: Gentlemen, I wish to say a few words on this subject, as one of the bystanders, who has got no gun himself, and may therefore be held to be amongst those who look on and see most of the game. After paying a very deserved tribute of admiration for the elaborate way in which these diagrams have been prepared by Captain Fishbourne, I will ask you to indulge me so far as to banish them from your minds, and let us for a few minutes go back to principles. In the first place it is a most unfortunate thing, that, just as Sir William Armstrong's admirers are lauding the things which we see before us, he has resolved to quit them, and to abandon the whole principle which he has hitherto advocated, adopting a competitive gun, which is not made of coils, but made of steel. Now that is the recognition of a principle which, before the Ordnance Committee, he acknowledged was a correct one. "Steel," he said, "I have no doubt is the best metal for guns; my only doubts are as to its preparation." He, in fact, left it to be inferred that he knew that it could not be prepared, because, had he thought that that was possible, it was evident that it was a better thing for him to do—to expend the unlimited time and money which have been at his disposal, in improving the preparation of a metal, which has a resisting power nearly double that of the best iron which he could hope to obtain, rather than go on finding out how good he could make a bad material. He has now said, "I do think steel can be made," but I was surprised to find that he was the Chairman of a large meeting (in 1859, I believe), before which it was absolutely asserted by one of those best qualified to make such an assertion, Mr. Bessemer, that such a metal could be made, that it had been made in large quantities already, and. that, given the time and money, any amount that was required would be forthcoming. Of course it is utterly absurd to say, "Give it me now, this instant, or you cannot give it me at all." That is an argument not worth meeting. With regard to the principle of rifling, which has been so much discussed, it is in vain to tell me that grooves of this or that fashion, hexagonal bores, or elliptical bores, can ever in any way give us a velocity approaching to that of a spherical projectile, having no more windage, where no duty of turning the projectile has to be done. It only remains therefore to ask ourselves, is the velocity a condition, without which you cannot go on, a *sine quâ non?* It is a condition which is of more value than any other in the operations we are called upon to perform? I am afraid I shall not be far wrong if I say that our engineering and artillerist friends from the shore have put before themselves the two qualities of long range, and great accuracy as the only ones to be sought in guns, utterly ignoring the fact that the first qualities for a gun are indestructibility, easy handling, and then the getting out of the projectile the greatest effects. We do not want, I repeat it, to make pretty little round holes, we want to smash iron plates, and he who bases his arguments against the smooth-bore on the fact of its failure to pierce, soft projectiles having been used, is no wiser than the Irishman who forgot to boil the peas in his shoes. You have got for the 68-pounder at last, with a great deal of trouble and trial, hard punches. Hitherto our friends, the artillerists, have been persistent in using much such a fallacy as I should have used, had I attempted to pierce rivet-holes in wrought iron plates with a cast-iron punch. They have at last availed themselves of that which had been offered for a very long time, a perfectly hardened shot, and the result has been seen; the velocity which the smooth-bore could give has had its due effect, and all have understood that there is no earthly difficulty in piercing any plates that we have with the smooth-bore guns, without resorting either to the flat-headed punches, or any form of rifling whatever. But I beg that you will not infer, as was inferred here on the previous occasion, that either I, or those who think with me, advocate the utter abandonment of rifling. No; we say distinctly, give us first the two most valuable qualities—velocity of impact at moderate range, and indestructibility of gun and projectile; after that give us as great a measure of accuracy and as long range as is consistent with those qualities. Now is it difficult to attain this? Has it not already been attained? Is there any question that without the use of lead, without the use of multigrooves,

without the use of any other than very simple forms of grooves, quite a sufficient measure of accuracy can be obtained—quite as much accuracy as is required, not only for all naval purposes, but probably for all land purposes? Yet if our friends, the artillerists, prefer a gun, which is always in hospital for their batteries, we shall be quite willing, I am sure, to permit them to take them, or help to drag them into the batteries, as we hitherto have done, even the very largest sized guns, and we will take the honest old gun which, with a simple form of rifling, on nobody's patent, and made cheaply of good material, will stand any usage to which it can be subjected, firing round shot as the rule, and elongated as the exception. The question of guns now reduces itself into getting the strongest metal, whether that be steel under new processes, or an alloy, such as the Austrians use, the advantages of alloy being that the guns are capable of being re-cast when damaged, which is worth consideration, and which has induced the employment of bronze artillery generally throughout the land service. Mr. Lancaster, I think, has very properly said that no grooves can resist more than a certain amount of wear, which will be not only something less than that which the smooth-bore would stand, for there is not so much work thrown on it; but he must allow me to remind him also that the question of weight comes into play, to destroy, and to make oval the bore of any gun to a certain extent, though not in smooth-bores to so great an extent as in the case of rifled guns, and that in all rifled guns you must expect that, in proportion to the number and fineness of the grooves, will be the ruin to those grooves, and the consequent future inaccuracy of shooting after no great number of rounds; I do not say with slow firing at a mark in target practice, but with such firing as those guns are made to be used for. We do not want to know what a gun will do when it is washed out and greased, and played more tricks with than I can recapitulate at this moment; we want to know what a gun will do when it is subjected to actual service, where it is put, not into the hands of trained gunners, but of the very boys of the ship, who may have to work the gun, for we cannot rely, as the artillery can do for most of their work, on a perfectly trained body of men, but we must occasionally rely on the most untrained and the rawest seamen, and the gun must be of such a character as that in their hands it will still not be an utter failure. Captain Fishbourne has shewed in his paper how the Armstrong has completely failed, but need we ask whether one Armstrong has failed a year ago, or two years ago, or three years ago, or whether the last and newest pattern has failed; if we once acknowledge that the system of lead-coating of shot is wrong from beginning to end, and not necessary; and, secondly, that the system of building up with weak metal when you can get a strong one, is wrong and not necessary; that, thirdly, the system of coiling guns never gives you a perfect weld; that by no possibility can any gun, welded or put together on the Armstrong principle, shew a perfect weld between its coils, for the scale, which evidently takes place from the oxide between the coils when they are wrapped round the mandril, never is and never can be taken out with certainty, though not visible when the gun is finished. We have not got, though I hope Mr. Bessemer will furnish us with it, steel of such a size and such a quality as to enable us to get our guns cast and bored, which is the very cheapest way of making them, or cast with a central core, cooling from the interior, perfect or nearly perfect as the Rodman gun. If we have not got that, we have got steel for hoops and for tubes, and I maintain it is very great folly to resort to a metal, like wrought iron, which is said to have an *enormous* tensile strength when it reaches 26 tons, when we can get another metal without difficulty which bears something like 56 tons. It is true that under certain conditions that metal will fail to support impact conducted in the way which Mr. Lancaster described; but with Mr. Barrass I perfectly agree, that that is by no means, or in any way, the strain to which the metal in the gun is subjected, that being entirely a compound of tensile strain and compressive force acting together. I have no doubt that Mr. Barrass is aware that Professor Barlow and Mr. Longridge went fully into the state of the metal in the guns, and the way in which each particular layer or annulus supports the strain.

Mr. Barrass: And Mr. Mallett.

Captain Selwyn: And Mr. Mallett. But I think the mathematical demonstrations, the early ones, were due to Mr. Barlow and Mr. Longridge. Those being the

circumstances, we have not to ask whether we shall now continue to build up the guns on the Armstrong principle. I do not ask whether they shall be altered, whether this hole shall be filled up to-day, or that hole to-morrow; whether a provision shall be made for the issue of gas, which seems to mean nothing less than the blowing off the breech, or whether the shot shall be coated with bronze instead of lead, whose galvanic action may be a little less rapid, but is nevertheless certain. No one, I am sure, can see that terribly diseased shot (pointing to diagram of exfoliated lead-coated shot), without feeling that electricity does mean something, and that it is not safe to expose such shot to the action of bilge water and salt water if they are affected in that way when in store in Woolwich Arsenal. If, then, these guns are defective in principle, if their shot are also defective in principle, to what are we to turn? Why did our ancestors, having tried rifling, for it was not unknown to them, give up these advantages, which were also known to them, and come back to the smooth-bore? Simply because they found that, given the wear of the guns, given the various inconveniences of loading, the diminished weight of shot, the want of accuracy of *ricochet* firing, which is no small matter as regards naval work—given all these and other things put together—they not being then aware of any system of rifling and strength of metal by which the use of round shot could be combined with it—they decided to give up rifling altogether, and to revert to the smooth-bore, and I do say that it is not wise to conclude that we are so advanced in science, and so well-informed, as that our ancestors must necessarily have been fools. We sometimes hear it said, "Oh, they knew nothing!" but they knew a great deal, many of them, and we have forgotten a great many things that they knew. And so it happens every day. We shall yet come to the adoption of rifling as the exception, and smooth-bores as the rule, for all natures of gun; nor will the 1,600 feet in a second initial velocity, which the smooth-bore now reaches, be by any means the limit of initial velocity, when we come to larger guns properly constructed; and if that be so, what armour-plate, what possible resisting structure, that you can put on the ocean, will avail against such guns, loaded with steel shot, which piercing the side, will make langridge of your own armour plates? I advert shortly to that, because I hope still further to bring forward the subject in a short time, and to shew you that we should not spend half a million from time to time in making experiments, which the next day demonstrates to be thoroughly useless.

Rear-Admiral Halsted: I only desire to make a few observations. We were addressed by a gentleman who styled himself a seaman-gunner, though not, of course, in disparagement of his position as a naval officer. Now, all that he described to us was simply and absolutely target practice, although the number of rounds amounted to 4,000. Now, I am ready to contend that target practice is but a means to an end, and that the end of the practice when perfected is really to meet an enemy, to fight a gun in action; therefore, I cannot understand how any target practice could overthrow the results read so clearly and distinctly to us last night, of the very first action in which those guns were actually tried. I cannot understand how he could overturn those results, or maintain that those accounts could not have been correct, in consequence of his own experience of what the gun had done, when he was at target practice with it. There is another point on which I would wish to say a few words. If the gun was to be made as perfect as possible to-morrow morning, what could it do? It is a gun which we are endeavouring to apply to use now; and the whole of our object and purpose in using the gun is to use it against armour-ships. Now, if it were as perfect as it can be made, it can but make an indentation to the extent of an inch and six-tenths in armour-plates. You may fire from it any shot, be they steel or gold, if you like, but that is the power of the gun. I say it is utterly impotent and powerless.

A Member: Which gun?

Admiral Halsted: I am speaking of the 110-pounder. And still more so as regards the gun which fires a shot of 70 lbs., with a 9 lb. charge; and still more impotent again is the other naval gun which we have been blessed with by our artillery friends, which fires a 40 lb. shot with a 5 lb. charge. It is literally and truly childish thus to arm the navy; if it was not very cruel, it would be ridiculous. With regard to my friend, Captain Selwyn's, observations about the steel round shot fired at

Portsmouth, I must solemnly protest against them. I make this plain statement, that any experiment which is made under conditions where you have not a single true representation of what a gun will have to meet when it comes to be proved in action, does not deserve to be called an experiment; or it should be called a false experiment, and it is not only false, but treacherous, absolutely treacherous. Now, the steel shot fired at Portsmouth were fired, not at a proved plate, but at an unproved plate, fixed temporarily upon the sides of an old ship.

Captain SELWYN: Pardon me, I did not refer alone to the Portsmouth experiments. You are quite aware that there are other and very important experiments, so to call them, which have been tried in America. The "Keokuk" was pierced by such balls.

Admiral HALSTED: My observations will still apply, for another reason which I will specify in a moment. Now, we know that in the year 1847 or 1848 there sat continuously a Committee of the House of Commons, upon the Ordnance and Navy Estimates. It produced a very valuable mass of Reports; and the Chairman of that Committee was the present First Lord of the Admiralty, the Duke of Somerset, then Lord Seymour. Now, on investigating minutely the account of the ages of wooden ships, it was found that at the age of 37 years, a wooden line-of-battle ship or frigate departs this life, and some other ship takes its place. Now, the old ship we have been firing upon at Portsmouth is 33 years old; she has very nearly arrived at her three score years and ten, and how many sound ribs she has, mercy knows. But again I refer to a statement that was made, and I am very glad that it was made, for I hardly would have believed that such a thing could have been done, if it had not been stated by Captain Heath yesterday evening. The new rifled gun known as Admiral Frederick's gun, the 7-inch gun of 6 tons 13 cwt., is now being sent to Portsmouth, to be fired at plates of some sort, I care not what sort, to be fixed upon the side of a ship, an old hulk, called the "America," built just 54 years ago, in the year 1810. Now, mark my words, because I wish to make a prophecy. In about ten days or a fortnight when this gun shall be ready, there will appear in all the professional puffing papers, and no doubt especially the *Times*, a wonderful account of what this gun has done; and we shall be told that it has pierced the old "America." Now, that would be in itself ludicrous. But the serious matter is, that the whole country will be told, that what it could do then, it could do also against the true, firm, new armour-ships, which, if it is ever fired at all in anger, it will have to meet. And not only that, but who will have to stand the brunt of the difference, which then inevitably must take place, between the performances of a gun when in true action and when at a false experiment? 70,000 seamen and officers of the navy will be held up to the country as incapable of fighting a true and successful action with the most wonderful of guns. It will be said, "see how those guns exploded and destroyed the 'America,' why cannot they do the same with the 'Gloire' or the 'Pervenetz,' or the armour-plated ships of other nations?" I solemnly protest against it; I solemnly protest that if any attempt is made to prove guns of any description intended to fight armour-ships, unless against true and absolute representations of armour-ships, unless the guns are fired not merely directly, almost as by an instrument at right angles to the surface of the target, but under all those circumstances of varying position, and varying distances, in which an action must be carried on—I say those who attempt to force our confidence in such weapons, only tried against such things as the "America," and who refuse to try them before real representations of what they will have to be proved by when the flag of the country is flying over them.—I say if they persist, as they seem to intend to persist, in doing so, they will do that which I will not here trust myself to describe.

Commander SCOTT, R.N.: Will you allow me to make a few remarks about these guns. First, I would advert to what Captain Dawson has said. Of course he spoke as a naval gunnery officer exercising trained men. He says, attention has been drawn in the wrong direction; there, I quite agree with him. With respect to the Armstrong 110-pounders, the muzzle nips of which, he says, have been ground out, I think there are about 700 of these guns in the service, and I am not aware that the nips of three of them have been yet ground out. Captain Dawson has told us of

his experience in target practice; I think it right to mention my experience in target practice also. It is only a short time since, at Newhaven, that they were firing the 110-pounder gun; and every time it was fired where do you think the people who were looking on went to? Why to a considerable distance. I went into a ploughed field behind, at an angle 200 yards to the rear; and I saw every other person shy the gun just in the same way. If you look at the chamber, you will observe there is room for a powder charge of 14 lbs.; it is said that the charge the gun was constructed for was 16 lbs. It was found that the charge of 14 lbs. tore the gun to pieces, and heated the bore much too rapidly, and consequently the charge was reduced to 12 lbs. Now, as you observe in the diagram, the charge of 12 lbs. does not fill the bore; and the result at Newhaven was, that if the charge was kept back to save the vent piece, the shock against the shell caused it to explode either *in* the gun or *at* the muzzle. Speaking from memory, I should say, five or six of these shells in succession exploded on one occasion at the muzzle of the gun; and at length, one or two of the shells burst in the gun itself, and cut up the rifling. When the cartridge was pushed forwards, close against the projectile, the result was to split the vent-piece. There were three or four vent-pieces split in the rounds that were fired. They continued to use 12 lbs. of powder, and to my astonishment I observed the vent-piece got fixed tight in the gun, requiring the efforts of five or six stout artillerymen ramming a long pole against it to drive it back. This occurred two or three times. Then it was said to the gunner, "you didn't put the tin cups in properly." I looked myself, and saw that the gun was expanded in the bore, and that the tin cups got thus pushed back over the vent-piece. I took up several cups, and found that they had been set back over the nozzle of the vent-piece. Now, supposing that had occurred in action, when the gun was warm, the vent-piece would have stuck, and who would have thought that the bore of the gun was expanded, and that there was a tin cup nipped in this way over the vent-piece? What Captain Fishbourne has said about the accidents which occurred in action at Kagosima, is similar to what occurred at Newhaven. As to the stripping of the shot; one shot that was fired tumbled just over the hill, and fell five or six hundred yards off, and several shots stripped—the lead on one occasion going away to the extreme right, close to the haystack where a policeman was, and on another occasion going more than a mile to the left, against the coast-guard chimney-pots. After this I observed there were lead globules rolling along the bottom of the bore, and had the gun been allowed to cool without cleaning, those lead globules would have stuck fast in the grooves, and the gun would not have hit a haystack. Without dwelling upon that further, I may say it was after this experience with the 110-pounder, and its muzzle-nip at Newhaven, that the grip of the muzzle was ordered to be cut away. I now wish to call your attention to the form of Sir W. Armstrong's grooves, which had originally two sharp corners; but as he drives the shot on one side only, the other acted merely as a trap to catch the lead. The specimen here is not his original groove, for it is rounded out just as my groove is. Well, you have had the muzzle-nip, and the stoppage occasioned by it in the gun was so great that when cut off, and thus shortened one foot, the gun gives about the same range as before. There is one fact that I would mention about that grip, because you hear many wonderful things about the Armstrong gun I heard Sir William explain that his shot actually obtained in the air a longer flight than was due to the same shot fired *in vacuo*. He said it floated upwards like a kite. But the fact is, that the shot, after passing the breech-nip, drops down and keeps along the lower part of the bore until it comes to the muzzle-nip, which throws it upwards. So he gets 6″ more elevation in the 12-pounder from the jump of the shot upwards than the line of the gun indicates. That is why the range in the field is actually greater at very low elevations than it would be *in vacuo*. You observe in this model where the breach-nip is. The shot is pushed in tightly against it, and is held there by the lead at the rear. The object of the grip is to keep the shot centred in the bore. If that grip were continued the whole way, it would have the intended effect; but now, directly after the shot has passed that nip, by which such a heavy strain is thrown on the gun, it is let down again into the lower part of the bore, and is then in the same position that it would have been without any

grip at all. If the breech nip were ground out as well as the muzzle-nip, you would get 10 per cent. additional initial velocity, and the life of the gun would be very much increased, and the vent-piece probably would stand. The nip in the shunt-gun is similar in its effects. Passing on, however, from these and other points in connection with these guns, which Captain Fishbourne has so admirably touched upon, that I need not further call your attention to them, let me come to what Mr. Lancaster has stated of the grooves breaking through, on their driving sides. Here is the 120-pounder shunt-gun of which we have heard so much. It was the one that was fired at Thorneycroft's bars, and was stated in *The Times* to have fired through plates of five, six, and seven inches thickness. But they were mere bars. The fractures in this gun are at the deep part of the grooves, not the bearing side. The pull of the shot is what cracked the inner tube through, which, although worn where the shot took the nip, is cracked at the opposite sides. If you take this 300-pounder shunt-gun, that again would go through the sharp angles on the loading bearing of the rifling. Now, in the early groove which I had for a light gun, I had this side sloped away, because I did not require great turning power for light shot in loading, but only a good bearing for the shot in coming out. But in the groove I have now got for the 100-pounder—the first was a 40-pounder —I require the groove merely to turn the shot in going home, and the loading side of my groove is just deep enough to do that. It is ·07 only, but the bearing side is one-eighth of an inch deep, just as you see in this muzzle of my 300-pounder. Both the shunt-gun and this are twice the full size; and in this 300-pounder only one-half the surface of the gun is taken out that there is in the shunt. Moreover, Mr. Anderson's experiments completely confirm what I now show as to requiring fewer grooves, for two of my grooves, given as you see in the Report of the Ordnance Parliamentary Committee, bear rather more strain than three of the shunt. I now beg to call your attention to this Table. When the guns mentioned below were put into competition, they had fired as given in the Ordnance Select Committee's Tables:—

Scott	300
Britten	263
Lancaster	138
Haddan	63
Jeffery	51

Some of these guns therefore had fired six times as many rounds as others with elongated projectiles. I do not want to dwell upon the amount of accuracy, but merely upon the fact that after the guns had fired 57 rounds in competition, two of them, Mr. Britten's and Mr. Lancaster's, were taken and slung up, and thus completed a large number of rounds, so that instead of bearing the strain which they would have had to bear in service; it was probably one-third less, and therefore much within the limit of the strength of cast-iron. I wish in the next place to call your attention to another Table, a very remarkable one, which Captain Fishbourne has given us. It shows the initial velocities with a charge $\frac{1}{10}$th the weight of the rifled projectiles. You will see that Bashley Britten's is 1213 feet, and the Armstrong 40-pounder, his longest gun—the gun that is said to give the best range—is only 1081 feet. What a remarkable difference with $\frac{1}{10}$th! What is that due to? To that constriction in the bore, and that constriction at the muzzle, and the excessive friction in the bore—and nothing else. In the other Table you come to the Armstrong 600-pounder shunt. The velocity given with a 610lb. shot, was only 1172 feet. The weight of the projectile in that case was eight times, and $\frac{4}{7}$ths the powder charge; I consider that a most valuable Table. The windage in this gun, however, is so small, only ·04, that if you were to take a hammer and flatten one of the studs on the projectile, no man could load with it. When the 300-pounder was last fired against the "Warrior" target, the studs stuck each time, and they could not get the shot home. When it came near the end of the bore, the shot could not pass the contraction there; at least they said the cause of the fracture of the shell was, that it was not close home against the powder. What a gun to load in action in a hurry! Well, if you cannot get the ball of a rifled gun home, then you must

take to the smooth-bore again. Haddan's, one of the cast-iron guns, gave a velocity of 1277, with a strength of powder of 1170. His windage was ·17, the weight of the projectile 7⅗ths that of the powder. The 600-pounder shunt-gun gave two feet less velocity. The windage was ·04, and its projectile in proportion to its powder charge, was lighter considerably. The Parrott gun shows a much more marked difference, 1405 feet velocity, with a nearly closed windage. With respect to the 600-pounder, also, we know that in a gun of that vast size, there is much more heat evolved, and heat is a powerful agent in expanding the gas of the gunpowder. Therefore, with that large sized bore of great powder charge, we ought to have much higher velocity. Why do we not get it? It is not necessary for me to go into the principle of these studs, to show why they wear down, and why Sir William has taken the form of the French stud. When the shot presses against the groove, as it must do in going along it, the stud wears away, and the consequence of the giving way of the fore part of the stud is, that the shot is always at a slight angle to the axis of the bore in travelling through the gun. Hence part of the effect communicated by the charge is in reality expended in wearing away the studs, instead of propelling the shot. I have to call your attention to one figure more. In 1862, the shunt 70-pounder, which was called the naval muzzle-loading gun, was tried at Shoeburyness. I have shown you that my cast-iron gun was considered in a sufficiently good state to be put into competition after 300 rounds, firing iron shot with soft metal in front, though in reality nearly all the rounds were obtained without any soft metal in front, because the old shot were picked up off the sand, and fired over and over again. There were only about fifty shot used, and with them the gun fired the fifty rounds. You will see with what accuracy, in the Table at 2° of elevation, as compared with Mr. Britten's, and again at 5° of elevation, as compared with Mr. Britten's at the same elevation. But I wish to call your attention to Mr. Bashley Britten's, in November, 1859, when he had just commenced firing, and in August, 1861, after he had fired a great number of rounds, and you will see there is a marked difference. His gun had greatly fallen off in accuracy; but the 70-pounder shunt-gun only fired 283 rounds, and was then unserviceable. It was expanded at the breech-plug, so that the fire hung round and its grooves were considerably worn down. This gun had six grooves. Now, what was the cause of this? There was the soft metal; but there was just the same work taking place that I have already explained; and the gun, although an expensive wrought-iron gun, was rendered unserviceable after a small number of rounds.

Rear-Admiral Sir Frederick Nicolson, Bart., C.B.: May I ask Captain Scott a question—that is, if the experiments alluded to at Newhaven, were experiments against an earthwork battery?

Commander Scott: Yes.

Sir Frederick Nicolson: I should like to say a few words—I will not detain the meeting more than two or three minutes. With reference to what happened to me in regard to an account that I obtained about those experiments. I was one day going to the train, rather in a hurry, when I met an officer who has taken the deepest interest in gunnery matters, in fact, it was Captain Scott himself; I saw that something serious had occurred. He asked with a very gloomy face if I had heard what had occurred at Newhaven; I replied that I had not. He then described what he has described to you this evening, with reference to the great misfortunes that had happened to the Armstrong guns. I had not much time to go further into the subject, and I went away to the train, feeling great regret that the gun at last had been entirely put on one side; knowing well that there were a great many guns of the kind made, and that a large sum had been spent in making them. However, when I got into the carriage, singularly enough, the first question I was asked was—"Have you heard of the experiments at Newhaven?" I said I certainly had. The gentleman who asked me the question, an officer of the Royal Engineers, then said that nothing could exceed the success of those experiments, that the practice of the gun was perfect, and the demolition of the battery something remarkable. He said, that no gun he had ever seen or heard of, could have breached that battery as it was breached by the Armstrong guns. In fact, he showed me a photograph of the battery itself. I said, "surely the Armstrong gun has been lamentably damaged, is

there not some elongation of the inner tube?" And I asked some questions, in order to elicit whether all those dreadful mishaps had really taken place. All I can say is, he assured me that he was present, and that he had seen nothing of the kind; that whatever had happened of that kind had certainly not come under his observation, though he was there with others for the express purpose of testing the gun. I thought that this was an illustration of how frequently on the trials of these guns we find that different observers are very apt to look at different sides of the shield.

Commander SCOTT: I should like to say one word or two in reference to the remarks of Sir Frederick Nicolson. I have had so little hesitation on the subject, that I have sent in my report to the authorities. One does not like to mention names, but I assert most positively, and nobody can contradict it, that these things did take place, that the inner tube protruded and expanded both ways after the firing (which I did not mention), and that there was a considerable leakage of gas, and that I did not mention. Several means were suggested of filling up the powder chamber, so as to prevent the fracture of the vent-pieces at one end, or damage the shell at the other. It was impossible to make a mistake. The shells were continually breaking up. It is true that with a large bursting charge the Armstrong shell did, wherever it hit, cut up the ground. Who could doubt that such a result would take place with a large elongated shell? But what of these general assertions about the gun being superior to any gun in the world? Captain Dawson, commenced by saying that he had no other experience of other guns; and then said that the Armstrong is the very best gun. This is what other people tell us; but they have not had experience; and they do not know what a rifled gun should do. So completely are some in love with this gun, that they cannot understand that there can be any other; and it is true that there is no other, for they have never allowed any other to be brought forward.

Commander SYMONDS, R.N.: There is one observation I should be sorry not to make at this meeting. I have observed that one gun, which has played a most conspicuous part of late years, has been totally ignored in the course of the discussion. It is a gun which has not only stood a very good test, the commercial test, having been advertised at a certain price to do a certain amount of work, and having been sold to the extent of some hundreds, I believe, to all the powers in the world, but it has also played a most conspicuous part in the operations in America. That gun happens to be a built up gun, though built up with steel; and I am quite satisfied of this, that only one motive, which I know all of you will appreciate, has prevented the gentleman who makes those guns from coming forward to-night. If you will permit me, I will offer a suggestion—that he should be asked to recount to you some of the most interesting information of which he is in possession, from those who have used the gun in America. I allude to Captain Blakely. I can speak with certainty on this point, that the gun has rendered good service there—no matter on which side—having produced effects on the turret ships which no other gun has produced, with (as I think my friend, Captain Selwyn, observed) steel spherical shot; and I think it is a gun which, in a discussion of this sort, ought not to be lost sight of. You will excuse my going further into the subject, as I do not pretend to be well up in the gun in question, but I thought it right to bring it to your attention this evening.

Captain BLAKELY: If it would be of any interest to the meeting to hear a few words on the practical side of the question, I can only say, having made a great number of guns, that I coincide with many of the opinions which Captain Fishbourne has arrived at theoretically. For instance, I find a great advantage on some occasions in using powder to burn in such a manner that the shock does not come very abruptly, the pressure of the powder being continued very much in the way Captain Fishbourne represents in the first column. The way in which I do this is to place a small air chamber behind the charge of powder; I think that is preferable to elongating the cartridge, or using a very slow-burning powder, because if we use a slow-burning powder we are obliged to use a large quantity; the Russian powder, for instance, requires exactly double the weight of ordinary powder to produce the same effect. With an elongated cartridge again there is a great

strain upon the gun immediately behind the shot, and there is a lodgment formed there, which eventually ends in rupture, I therefore put the cavity, the air space, behind the cartridge. Within the last few days I have received favourable accounts of the performances of guns so arranged, which have been tried on a very large scale. The bore is 13 inches in diameter, and the gun fires 650 lb. shot with 55 lbs. of powder. One word about rifling. It is generally supposed that the driving surface of the grooves must be worn out. That depends upon the size of that surface. If the surface is large enough to bear the pressure, little wear will take place. It is a mere question of surface. I may be allowed to criticise one thing about Captain Scott's system of rifling. You will observe, no matter whether the shot may be large and bearing upon one point, or whether it is small, there is only one line bearing, that is a very small surface, so small that it must eventually wear. I have rifled a great number of guns with Captain Scott's permission, using this curve for the purpose of centring the shot; but I have added to that, first of all, a radial surface, which will always give a large bearing surface, to turn the shot, and then I have Captain Scott's curve to bring the shot into the centre. In the shunt system, Sir William Armstrong brings the shot into the centre of the gun, and makes the axis of the shot coincide with the axis of the cannon, by nipping several, I believe fifty studs of copper. Now, I fancy that must be an exertion very much greater than is necessary for so small a purpose. In the shot, weighing no less than 650 lbs., and of which this is a model, I effected the same purpose in a different way. I had a radial bearing surface for turning the shot, and I then added an inclined surface for the purpose of making it slide into the centre of the gun. Though I gave a rather large surface of pretty hard bronze to turn this shot, I made simply a few copper nails do the work of bringing the shot into the centre of the bore; and I found that that was quite sufficient. There were eight copper nails, and the upsetting of these eight nails was sufficient to lift the shot and put it in. 650 lbs. was all the force that was necessary; and 650 lbs. could easily be applied by a small piece of copper. I quite agree with Captain Fishbourne also as to the great facility of rifling guns in such a manner that they can fire round shot. In fact, I scarcely ever manufacture any guns where I do not employ round shot. I see on the table a specimen of a 100 lb. steel shot made by me. I will not discuss any question not raised by the author of the paper, but I cannot sit down without remarking that the system of rifling we adopt, the kind of powder, and material of the gun and shot, are of very little importance, in fact, no more important than the colour we paint the guns. The only real question of importance is the size and power of the guns we are to use. If the British navy persists in refusing to use any guns above the power of 68-pounders, which is the most powerful gun at present in the English navy, the ships so armed will be impotent against the navies of almost every other country in the world.

Mr. Reynolds: I think there is a light in which the subject of material has not been considered, at least, I have seen no record of any discussion in which it was looked at from the point of view I am about to take. It is well known to engineers, and always taken into account in selecting materials, that some irons are more extensible than others, and generally the more extensible material has less original tensile strength. I have no doubt that the particular iron—made, I believe, by Messrs. Taylor of Leeds—which was used for the coils of the Armstrong guns, although possessing considerable tensile strength—probably fully 24 tons to the inch—was not iron that would bend as freely after nicking, or bear stretching when cold to as large an amount, as a softer and weaker iron; but it does not therefore follow that it was an unsuitable material for hooping guns. For other purposes these qualities may be highly desirable, for such engineering purposes, for instance, as the chains of a suspension bridge. The strength of Chelsea bridge has been a matter of much discussion. I happen to know that the excellent iron of which those chains are made will bear from 23 to 24 tons per square inch, and stretch cold nearly 20 per cent. before breaking. For such a purpose this is a most valuable quality, but it does not follow that it is so for guns. The material, with the manufacture of which I am at present most connected, is steel, and it may be worth while to note the direction in which manufacturers, some at least, are turning their attention in pro-

ducing steel for guns. In the establishment with which I am connected, all the steel used for any special purpose of that sort is tested, not only for tensile strength, though that is of importance—not that tests made by the machine at Woolwich, if it is not altered since I had a knowledge of it, would be of any value whatever, because the specimens operated upon were too short—but it is tested also for transverse strength and resistance to impact; and this is done on an extensive scale, taking a piece the size of a railway axle, say four inches in diameter, and testing it by a succession of blows with a drop of 14 cwt., which has a range of 40 feet. After each blow, the specimen, if bent, is reversed, so as to have a succession of flexures in opposite directions, the sum of which is taken for each separate material, of which the composition, specific gravity, &c., are registered; the amount of endurance is thus thoroughly ascertained. But it does not follow that the material which will do the highest duty under these severe tests is any the more suitable for guns. It seems to me—and it is a matter upon which we are now going to make further experiments—that what we want is the material that will carry the highest tensile strain through the greatest space without taking a permanent set. The amount of work that may be done by a bar of soft iron in stretching, the number of tons per square inch that it takes to stretch it, multiplied by the whole distance through which it moves before it ultimately breaks, may possibly be greater than that of the very best quality of steel; but when it has taken a permanent set it is useless for guns. I am told that the iron hoops, with which the Armstrong guns have been cased, have become loose; that is the result of using an easily extensible iron. It must be admitted that there is less danger to the gunners if the material will stretch in that way instead of breaking, but the gun for all practical purposes is destroyed. An illustration of the fact that the endurance of a material not extensible and not capable of flexure in the sense of permanent set, may be the most suitable for the purpose, may be seen in a sword-blade. In its normal state of soft steel, it will bear only a very limited amount of flexure without taking a set; but after being hardened and tempered, which would reduce its power of bearing permanent extension, it will not only require a greater force to bend it, but it may be bent double without having suffered any injury, as far as we know, and recover its form perfectly; and it will bear that test over and over again. It seems to me that the direction in which Captain Blakely, Mr. Anderson, and others, are going, is right so far; they are making the inner tubes of the guns of steel; and the great object of experiment should be, to find that quality of steel which, without taking any permanent set and without fracture, will bear a high strain through the greatest distance. I would merely mention that we (the firm of Naylor, Vickers, and Co., of Sheffield) are organising a series of experiments to ascertain that particular point.

Admiral Sir GEORGE SARTORIUS: An observation was made by Admiral Halsted that the vessel upon which some experiments were made was a very old vessel. Now he must remember that vessels are constantly repaired, and that a vessel may be 50 or 60 years old, and at the same time the timber be very good and strong; so that according to the effect produced upon the timber, you may very fairly judge what will be the result in action. With regard to distance, we must remember that no naval action has been decided, or can be decided at a distance of more than 1,000, or say 1,200 yards—much more frequently it is within 400 or 500 yards; therefore, extreme range and extreme precision are not necessary in naval actions. It is true there may be circumstances, for instance, in combined operations, as in covering troops and landing boats, when a gun that has a great range may be necessary, and will be necessary no doubt, but the gun for use in naval warfare is such a one as has been described more cleverly than I could do by Captain Selwyn, who has anticipated me in some of my remarks. The gun that we require is a gun that will make the greatest hole with the greatest number of splinters, and carry from 1,000 to 1,200 yards. That is the gun that we require, and that we must beg those gentlemen who are gun makers to give us. Give us that gun, and depend upon it, we shall do as well as our forefathers did.

Captain FISHBOURNE: I will first refer to the observations of my friend, Captain Dawson. He commenced with finding fault with what I did not say; but having exhausted your patience, I could not introduce other matters. I was dealing

rather with principles than with mere details. But I objected to the sights on a former occasion, and I stated in general terms, what Captain Dawson has done in detail, while he said he was advocating the multigroove system he supplied particulars as to defects which I had not touched upon. He then alluded to "theorists," meaning to say, that his facts were reliable facts, I suppose because he saw them, and implying that mine were mere theories. Well, I gave a number of facts on the authority of other people. Any man who has ever been under fire, must know that not one man in a thousand is cool on first entering fire: and it is not as Lord Byron says, until his ear gets more accustomed, and less nice, that he acquires that absence of excitement, which will enable him to use with certainty, complicated arrangements in guns; therefore, the normal condition of coming under fire being that of excitement, the multigroove gun, from its complication, is utterly unfitted for the general purposes of warfare. He says, that I said that everybody agreed in the condemnation of the multigroove. I did not say that, but I *believe* that every one, himself included, condemns the multigroove, though he is reluctant to say so. But I need not enter into that question, for the inventor has given it up; and all that is left us, are a few little nicknacks, as the small change of our three millions of money. Captain Dawson said that I had proved too much. Well, I do not know what he means. "Too much" has two significations. I am quite aware that for the admirers of Armstrong's guns, I have proved a great deal "too much." I do not know precisely whether he means that, but if he does not mean that, instead of going into matters not mentioned in the paper, it was his business to show this meeting, where I had proved too much, and how I had done so, he was bound to support his assertion, but he has not attempted to do so; he has not shewn a single point where I have exceeded in any way, facts, or reason, or figures. Tables have been framed to prove the inferiority of the smooth-bore. Allow me, also, the run of the multiplication table, without limitation of law or reason, and I will give any amount of such facts. Such is their character, that when we come to winnow them we find there is one fact among a number of fancies. With regard to Mr. Lancaster's remarks, I quite feel with him, that *time* has been utterly ignored in all these questions, and that the disruption of these guns has been, because time has been lost sight of, and what has been claimed as an advantage, has been really a disadvantage. With respect to a remark of Captain Blakely's, I dare say it was a *lapsus*, he said it did not matter with respect to rifling what the grooving was, any more than the colour of the gun. I must take exception to that, as it is quite clear that the multigroove gun is in process of disintegration from the very first moment of proof, because it is subjected to a degree of pressure, that the metal is not capable of bearing. It is established that the use or disuse of that system of grooving, is of very material consequence, and that it is most important that it should be abandoned as wrong in principle. Why I dwell on it now is not so much in respect to the past, as the future. I understand—which is a proof of the fact that I mentioned, but which Captain Heath controverted—that the authorities have come to the conclusion that this multigroove gun has been subjected to too great a tension, and have determined to reduce the charge and the size of the chamber. Now, what will take place? Just what is taking place now. Experiment has established, that if powder is burnt in a closed vessel equal to its own volume, the chamber or vessel containing it, is subjected to a pressure of 90 tons to the square inch. Reduce the charge (within certain limits) and contract the chamber equally, and the same conditions will obtain. As long as a shot is used that offers the same obstruction as in the multigroove, and closes up the chamber, there will be the same amount of initial tension, and the same destructive energy exercised upon the chamber, vent-piece, &c. Common sense would dictate, that if the gun will bear such a tension, its strength should be made available for the purpose of projecting the shot with greater velocity, making it what it is not now—effective against iron-plates. I have put the tension at 18 tons, as the chambers break up and crush the metal, and 17 tons is the pressure at which this action occurs. Sir William Armstrong gives it as his experience, and he states it calmly, that if he subjects his gun to a pressure that would give the shot initial velocity exceeding 1,200 feet, the metal yields. Does Captain Dawson believe this? Is Sir William Armstrong ignorant on

this point? If so, an Appendix to the Queen's Regulations recognises that fissures and flaws in these guns is their normal condition. I suppose gentlemen conversant with the subject would tell us that that is not the normal condition of metal. Look at that shot on the table, look at the metal that we see every day in machinery is that full of flaws? Do they not cast aside articles with flaws as defective? but here they are recognised as inevitable, as matters of course. Every gun comes out not with a bill of health, but with a long bill of defects; and there is a person appointed, I know not of what rank, for the purpose of taking a list of defects of every new gun. From its birth, the multigroove is in process of disintegration, and the Table which I gave in proof of the very high tension is very important; I dwell upon it because Captain Heath implied that it was empirical. It is to a certain extent empirical, but every one knows that it is very common to use empirical, as stepping-stones to accurate formulæ. There is an anecdote about Sir Astley Cooper, that you may remember; some one once charged him with being unchemical in his compounds. "Well," he said, "I do not mind being unchemical, if I can save my patient." Now, I want to save the patient, John Bull, from the infliction of another three million blister; and if I effect that, I do not mind being charged with being empirical. There is the fact admitted by Sir Wm. Armstrong, confirmed by these fissures and flaws; and there is no other way of accounting for them, except that the gun is subject to a pressure beyond that which it will bear. Other guns in the Table are cast-iron; and I have put them at a little below what is supposed to be the safe tension to which they can be exposed. They burst at 300 and 200 rounds, and in the shunt-gun, at four rounds; so that we are not far wrong. These figures are not meant as showing the absolute tension, but in order to put before your minds graphically, what is better done by figures than can be done by words. Captain Heath said it was impossible that the plan proposed could be carried out. Captain Blakely has explained the manner in which he has arrived at it. I alluded to gun-cotton, which, in proportion as it is pressed, gives a higher degree of elasticity, and there can be no difficulty in filling a portion of a cartridge with gun cotton, that will yield a pressure, on ignition, equal to 2 tons to the square inch, a second portion yielding 4 tons, a third yielding 8 tons, and a fourth yielding 12 tons or more. The first section is near the shot, and is first ignited, to give it motion slowly, in order not to injure the gun by undue tension. Then the greater pressure from the other sections follows the shot up, and gives it a rapidity of translation that no other transmissive arrangement of the power could do. The gun will be subject to a minimum tension, and yet a maximum result will be obtained. The adoption of this principle would admit of the use of guns of a far inferior quality of material, and if of good material of larger size. The recoil would be less with equal weight, and would permit the use of guns of a larger calibre on board ship. I need not trouble you further, except to allude to the initial velocities quoted by Captain Heath, in respect of which he gave only half the facts. You were told in contradistinction to the initial velocities that I gave, that the shunt-gun gave 1,600 feet, I think, comparing that with the velocity obtained from the old 68-pounder, that has not been improved since the dark ages; not venturing to compare it with anything else, with the new smooth-bore, for instance—for Sir William Armstrong has come round to the smooth-bore, and some papers give him credit as though it was his invention. I contend, that it and the new competitive guns are the *United Service guns*; and I protest against Sir Wm. Armstrong taking credit, or being credited for them, by the Ordnance Select Committee. They should go into competition as the United Service guns. I am drawn, however, from my subject, which was about the shunt-guns, that Captain Heath told you gave certain initial velocities, but did not tell you the further fact, that these guns *burst*. What would be said if I produced such a fact? The 150-pounder that I have already mentioned, gave 2,100 feet initial velocity, but then it burst. It and they were very much like the Frenchman's horse, just as he was getting used to live without eating, he died. Such is the character of a great number of the facts which are brought to bolster up an erroneous system. The segment-shell, now that all else is given up, is put forth as the great and important invention of Sir Wm. Armstrong; yet that is not his invention. Here is the patent:—"My third improvement consists in making a shell

" or grenade, having a cavity in the centre for the powder, and between the cavity " and external case, a number of pieces of metal closely packed in one or more layers, " in such a manner that when the shell bursts by the explosion of the powder, those " pieces shall become independent missiles." But the specification is Mr. Holland's, of 1854. Yet it is claimed by Sir William; I contend, that Mr. Whitworth, or any other person having a gun in competition, ought to have had the advantage of this as belonging to the public, for whom it should have been purchased from Mr. Holland, and who ought to have had the credit of his own invention. Lieutenant Reeves, R.A., however, has invented a case-shell, which far exceeds the segment-shell in value.

My object has *not been* to advocate any particular gun, but to deal with principles, with a view to the future, and I have introduced guns or systems, only so far as they were necessary to that end, which was the less necessary, as I had done so in 1862.

The CHAIRMAN: Before we separate, I am sure you will join with me in expressing your thanks to Captain Fishbourne, for the important paper which he has been good enough to read; and I think we may also add our thanks to those gentlemen who have joined in the important and interesting discussion to which that paper has given rise.

LECTURE.

Friday, February 5th, 1864.

Colonel J. P. YORKE, F.R.S., in the Chair.

BALLOON RECONNAISSANCE.

By CAPTAIN FREDERICK F. E. BEAUMONT, R.E.

MR. CHAIRMAN, LADIES AND GENTLEMEN,—I have been asked to give a lecture on military reconnaissance by the aid of balloons, and I have agreed to do so, not, I can assure you, from a belief that I can do justice to the subject, but rather because I have taken a considerable interest in it, and I am unwilling that any effort on my part, however humble, should be wanting which might contribute to the advancement of practical science. Furthermore, if it serves no other purpose, this lecture may give a certain amount of publicity to the subject, and it is a fact becoming daily more apparent, that most new things are aided by publicity, and finally started under pressure from without.

The conservative element is so strong in this country, and we are so much averse to change, that generally it requires to be shown, not only that a thing is good, but that there is a positive evil, in some shape or other, in standing still, before we can make up our minds to change; and I have, too, heard it remarked, that under the pressure which resistance to innovation produces, we change, when we do begin, rather too quickly, gulping down reforms as we would take a dose of physic, instead of spreading them over such a time as would insure our getting the collective wisdom of many brains.

However that may be, making war by means of balloons certainly does not look like standing still; and even in this age of novelties it is somewhat startling to be told, that armies cannot be considered to be properly equipped unless they have with them the means of taking an occasional fly; and that the time has come when the only element of the four remaining unused is about to be made one of the slaves of war. Earth holds us while we fight our battles, fire drives our ships and propels our cannon-balls, water bears our navies, and now air is to give us the power, as it were, of omnipresence.

I shall not weary you by recapitulating what I have no doubt most of you already know—the early history of balloons; nor shall I follow the first inventors through their difficulties with hollow spheres, that were to rise through the abstraction of the air from their interiors, which idea was superseded by the Montgolfière, or heated air balloon, which again was improved upon by the substitution of gas for air. I may point out, however, that the theory of a balloon was correctly struck by the idea of an empty sphere, which would have a tendency to rise in the air with a force exactly equal to the weight of the air abstracted.

The pressure of the atmosphere on the outside of an exhausted receiver which is fatal to this plan, is got over by the substitution for the vacuum of a gas whose elasticity is equal to that of the air outside, but whose specific gravity is less—illuminating gas, or rather, which is generally used, a particular gas specially prepared so as to be light, and hydrogen, are the only gases used.

I should here do justice to our ancestors, and state that there is nothing new in the application of balloons to the purposes of a military reconnaissance; indeed it is one of the first uses that suggested itself (as it naturally would do) to the originators of balloons.

The following extracts from a paper written by Lieutenant Grover, R.E., show where they have been employed. Lieutenant Grover says:—

"The French, by whom the actual idea of balloons was originally "conceived and carried into effect, were also the first to discover the "adaptability of their invention to practical purposes. At the com- "mencement of the Revolutionary War, about ten years after the pro- "duction of the Montgolfier balloons, an Aërostatic Institute was "formed by command of the French Directory (at the suggestion of "Guyton de Morveau) in the Ecole Polytechnique, and under its "superintendence reconnoitring war balloons were constructed by a "M. Couté, and supplied to each republican army in the field. The "army of the Rhine and Moselle was provided with two, viz., the "'Hercule' and 'Intrépide'; another named the 'Céleste' was pre- "pared for the use of the army of the Sambre and Meuse, the 'Entre- "prenant' for the army of the North, and a fifth was destined for the "army of Italy. That attached to the army of the Sambre and "Meuse, under General Jourdan, was first used May, 1794, by Colonel "Coutelle, at Maubeuge, before Mayence, in reconnoitring the enemy's "works. This balloon, which was twenty-seven feet in diameter, and "took at first fifty hours to inflate, was retained to the earth by two "ropes, and the aëronauts communicated their observations by throw- "ing out weighted letters to the General beneath. After this method "of reconnoitring had been successfully practised four or five days, a "17-pounder gun was brought down to a neighbouring ravine, and "(being thus masked) suddenly opened fire upon the balloon. Several "shots were fired without effect, and the machine was then hauled "down; but the next day the gun was forced to retire, and the "reconnaissances were then carried on as before. After two or three "weeks the balloon was moved to Charleroi, distant from Maubeuge

"about thirty-six miles. To save the expense and trouble of another "inflation, it accompanied the troops at a sufficient height to allow the "cavalry and baggage waggons to pass beneath, ten men marching "on either side of the road, and each man holding a separate rope "attached to the balloon, which was thus retained at its proper elevation. After making one observation on the way, the balloon arrived "before Charleroi at sunset, and the captain had time before close of "day to reconnoitre the place with a general officer. Next day they "made a second observation in the plain of Tumet; and at the battle "of Fleurus, which took place on the following day, June 17th, 1794, "the balloon was employed for about eight hours, hovering in rear of "the army at an altitude of 1,300 feet.

"The Austrians after some time discovered it, and a battery was "opened against the aëronauts, but they soon gained an elevation out "of the range of the enemy's fire, and the information concerning the "Austrians' movements (which they were enabled in this manner to "supply to General Jourdan) contributed mainly, it is said, to the "success of the day,* the result of which was the loss to the Prince "of Coburg and the allied armies of all Flanders, Brabant, &c."

"The next battle that the French gained through the assistance of "a balloon was near Liège, on the Ourte river. As the Austrian "officers afterwards said, 'One would have supposed the French "general's eyes were in our camp,' for they were attacked at the "critical moment of sending off their guns and baggage by the rear, "the French (though occupying much lower ground than the Austrians) "having been intimately acquainted with all their movements by "means of their balloon. The result of this battle was of very considerable importance to the French, as it gave them all the country "between Liège and the Rhine.

"They afterwards used reconnoitring balloons at the sieges of Mentz "and Ehrenbreitstein, 1799. A balloon was also attached to the army "sent on the memorable expedition to Egypt. What service it rendered there we are not informed; but after the capitulation of Cairo "it was brought back with the remains of the army to France, and "was afterwards used by MM. Biot and Gay Lussac in their celebrated "ascent for philosophical investigations."

The French again made use of balloons in their Italian campaign of 1859, a reconnaisance having been made by the brothers Goddard before the battle of Solferino on the 23d of June; and the latest employment of these engines of war is that by the Federals in the present American war. As I had an opportunity of inspecting their

* A Dr. Miers, of Hamburgh, in his journal that he published on his excursion to Paris tells us that :—"J'ai vu à Paris et à Meudon le Capitaine Coutelle, le même qui le 17 Juin, 1794, montoit le ballon qui dirigeoit la merveilleuse et importante reconnoisance de l'armée ennemie à la bataille de Fleurus, accompagné d'un Adjutant-Général. Je lui ai parlé de son voyage aérien, pendant cette bataille, si decisive par suites dont le succès est du en partie à cette expedition aerostatique d'après le jugement unanime des personnes impartial. Coutelle correspondit avec le Général Jourdan, Commandant de l'armée Francaise, par les signaux de pavillon convenus." —*From Major-General Money's Pamphlet.*

apparatus, and made one or two ascents before Richmond, I shall speak further of their arrangements.

I have now done with the past, and shall take the art as it stands at the present time. I shall commence by pointing out to you the nature of a balloon reconnaissance, and showing what is and is not expected to be gained thereby; and shall conclude by explaining the practical details of the apparatus necessary to a complete balloon equipment.

Everybody who has been with an army in the field must have noticed the anxiety with which reports from the front are looked for, and the care taken both by the quartermaster-general's and engineers' department to obtain information; and those who are strangers to active war must have remarked how often the word reconnaissance appears in newspaper reports of operations. Now a reconnaissance simply means an attempt to gain information of the whereabouts of an enemy, and as all dispositions should be made, if possible, with a certainty as to his position, it follows that the results of a reconnaissance are often of invaluable consequence to a general; and even when nothing has been discovered, a sense of safety in the knowledge of the absence of danger is produced, which can hardly be called only a negative advantage.

Those people, whose duty it is to survey or explore a country in the vicinity of an army, do so by penetrating in various directions so far as they dare go, by following out the rivers, streams, and roads, and, above everything, by taking all opportunities of extending their vision. An intelligent officer climbs the highest tree, ascends every rising ground, and gets to the top of any house that may offer him a chance of seeing more than he could do from the ground; in fact, he has never seen far enough; but with all his energy, it frequently happens, or to speak more correctly, it almost always happens, that his sight is bounded by woods, hills, or other obstructions, and this is chiefly the case in a closely wooded country, where he would most wish it otherwise. The highest tree is but a few feet above its neighbours; a house, if there, offers little better opportunity; while church steeples or monuments are seldom met with. The advantage of a hill overlooking a plain is lost with a change of position, and to see over a rising ground, however slight the rise may, is absolutely impossible. Considering the above, I think it will be concluded that if a reconnoitring officer could find a pillar like the Monument erected, say every mile of his route, it would much facilitate his operations. By one sight from such an elevation, he would be able to trace the course of the rivers, and roads, running beneath him; and he would be able, without traversing, to lay them down in some sort of way; he would, furthermore, be able to recognise the correctness of a map, should one be in his possession. Within his range of vision, the officer would be able to have certainly a much better idea than he could have from the ground, of the disposition of an enemy's forces; or if it so happened, to establish the fact of the ground being unoccupied.

Now, the balloon is proposed to supply this desideratum and nothing more. It is intended by its means to have a monument permanently

with an army, but with this difference, that in place of being established only every mile, it can be set up at will; and in place of being only some 200 or 300 feet high it can be 1,000, and its range even further extended. It is true that as at present arranged it cannot be said to be always available, but of that I will speak again. I cannot myself see how it can be doubted that in some, if not in many instances, to obtain an extended point of observation must be a great advantage. The information brought from the balloon may often be negative, that is, the report will simply affirm that no enemy is in sight, or that no change has taken place since the last ascent; still the time will come when the intelligence will be invaluable, as containing new or affirming doubtful facts, and at the worst the balloon can only be set down as a not very expensive incumbrance, when it should be remembered that its expense is, comparatively speaking, insignificant, the full cost of a suitable apparatus being roughly some £500 or £600; and as regards its being an incumbrance, it can be conveyed with as little inconvenience as three baggage waggons.

Many people have asked me rather sarcastically how I proposed to win battles by balloons. They had evidently borrowed their ideas of balloons from Tennyson's somewhat vague prophecy, where he says:

> For I dipt into the future, far as human eye could see,
> Saw the vision of the world, and all the wonder that would be;
> Saw the heavens fill with commerce, argosies of magic sails,
> Pilots of the purple twilight, dropping down with costly bales;
> Heard the heavens fill with shouting, and there rain'd a ghastly dew,
> From the nation's airy navies grappling in the central blue.

and fancied that iron-plated balloons and Greek fire poured upon the people below were not altogether beyond my notions.

Now, it will have been seen that the balloon is to take no active part in the fighting; in fact, when within range of the enemy's guns it should be moved (though I may here remark that owing to its position and uncertain distance, a balloon is an extremely difficult thing to hit, and when struck, except by a shell or on the car, little damage would be done that could not be easily repaired); and that, in fact, the balloon is supposed to be of no assistance to the general whatever, beyond placing him *au fait*, or as the Yankees call it, "posting him up to the latest date".

I will now give you the results of such reconnaissances as I have seen made, and make some remarks on the way in which they were carried out.

The theory of ballooning is so simple, and the practice of it so difficult, that opinions as to its success must be based upon the result of actual experiment rather than foregone conclusions.

The first time that I saw the American balloon used was in the spring of 1862. I joined M'Clellan's army at Cumberland, landing on the Pamunkey river, one march below the celebrated White House, and I accompanied their advance to Gains Mill, on the edge of the valley of the Chickahominy.

I may here mention that I came among the Americans a perfect

stranger, with no introduction of any sort or kind, but that after I had got clear of the Washington officials, by whom my journey had well nigh been frustrated, I was shown every possible attention, received at the head-quarters of the army with hospitality, and given every facility for going and seeing where and what I would.

It was at Gains Mill that I first saw the balloon. It was then with the advance guard of the army, under General Stoneman, the main body being some two days' march behind, and so far as I could learn no difficulty had been experienced in causing the balloon to accompany the advance, which, indeed, is its proper place. It can be allowed in still weather to rise some 20 or 30 feet, so as to clear obstacles, and the men holding the guy lines, march regularly along. If the wind be at all high, it is necessary to discharge the gas.

The staff and apparatus were as follows:—one chief aëronaut, professor, and a civilian, but who was given, I think, military rank; one captain's assistant, and 50 non-commissioned officers and men. There were then present with the army two balloons, and two generators. Whenever the weather was sufficiently calm, the balloon was up hovering over the camp at altitudes varying from 500 to 1,000 feet, and reports were sent in daily, or oftener if need be, of the observations taken, noticing any change that might have taken place in the disposition of the troops, or appearance of any works visible. Evening and morning were found to be the times generally best suited for observation, as the air was clearer and the shadows were larger.

The balloons were made of the best silk, very strongly sewn, and were inflated with hydrogen produced from two generators, which were simply large wooden boxes, lined with some material not acted on by sulphuric acid, and mounted on wheels, each being capable of being drawn by four horses. The gas was generated by the action of sulphuric acid and water on iron, and was passed through two lime purifiers before being delivered cool into the neck of the balloon. The balloons kept their gas for a fortnight, that is, having been filled up, they still retained, after that time, sufficient ascentional power to be of use.

The guy lines were three in number, one thicker than the other two, the intention being that one should take the main strain, the others acting simply as guys.

The method of manipulation was carried out as follows: the main rope was passed through a snatch block firmly attached to the ground, and each of the three having been manned by some ten men, the machine was allowed to rise. Communication was maintained when the altitude was small, by shouting, and at 1,000 feet, messages were written on a bit of paper, and dropped with a stone to the ground. Telegraphic communication was also established. Indeed, at the battles that resulted in M'Clellan's being driven back from Richmond, the instrument in the car of the balloon was in communication with the line wires leading to Washington, so that the President sitting in his closet might literally receive earlier intelligence than the general in the field, of the turn the battle was taking; this, however, was a vicious refinement, for it is needless for me to point out, that the only

information the government should receive, ought to come direct from the general in command.

It may be well here to explain the position of the army at the time I actually saw the balloon used.

M'Clellan, who was in command of the army of the Potomac, especially destined for the capture of Richmond, had landed with his forces at Fortress Monroe, an ordinary bastioned work on the extremity of the Peninsula, formed by the York and James rivers; he had advanced against the lines of Yorktown, which stretched from river to river some 30 miles above Fortress Monroe. The Confederates abandoned their position so soon as M'Clellan's arrangements for shelling it had been completed. I do not think, however, they had any further intention than that of delaying his advance as long as possible. Past Yorktown, he advanced, with his right resting on the York and Pamunkey rivers, until he reached the White House situated on the latter, at the point where it is crossed by the West Point and Richmond Railway. Here he left his water base of operations, and was obliged, for his supplies, to trust to land carriage. From the White House to Richmond is some 50 miles, and Gains Mill, which is on the bank of the,—so to speak,—Chickahominy valley, is about 10 miles from Richmond. The army, 100,000 strong, took up, in the first instance, a position entirely along the banks of the Chickahominy, some six miles on either side of Gains Mill. The left was then thrown forward across the stream, and this was the last onward movement made, as the Confederates succeeded in repulsing the advance, and at the same time attacking the White House position, cut off M'Clellan from his base of operations, and obliged him to beat a hasty and disorderly retreat to the cover of his gunboats on the James river.

Nature, in that part of Virginia, is prolific in vegetation. A great part of the land is still covered with trees, and as the ground is undulating, it was very unfavourable for making a reconnaissance. At Yorktown many ascents were made, but I did not hear that they had been attended with any advantage beyond the indirect one of looking into the enemy's works. No sorties of any importance were attempted, hence there was no particular gathering of men to be noticed, and the prolongations of the faces of the batteries, necessary to establishing correctly the position of the counter-batteries, were known by observation from the ground, so that on the whole there was little scope for the balloon; in such a position, however, plenty of circumstances *might* arise which would prove its value.

At Gains Mill I made one or two ascents, and had there an opportunity of judging practically of the advantages to be derived from a balloon reconnaissance. From the top of the hill whence the balloon was raised, my vision was bounded all round by trees, so that I could in no direction see further than half a mile. As we rose, it was curious and beautiful to watch the gradual extension of the horizon; first, the country appeared all wood, from the eyes enfilading, as it were, the tops of the trees; next open spaces began to shew themselves nearly beneath the car, and then, as the altitude increased, they could be seen further out.

Looking more closely, I could distinguish roads here and there crossing the open, and where the direction was favourable I could trace them through the woods.

The Chickahominy, like a silver thread, half hid in the line of trees that shaded its banks, lay beneath me, all signs of its forming the centre of a valley being lost, as from the car of a balloon one cannot trace the difference between hill and plain, owing to there being nothing to guide the eye.

After getting, as it were, my air legs, and becoming accustomed to the situation, my first anxiety was to see the Confederate soldiers, and my next to look at Richmond. So far as the enemies' army was concerned, I could only see their pickets thrown forward to the banks of the Chickahominy, with their supports on the heights behind them; no army was near them, unless it was concealed in the woods, whose tree tops only I could see. These woods were certainly big enough to have contained 50,000 men, provided they remained still, and did not light any fires, both somewhat unlikely provisions.

But Richmond, the looked-for goal, the capital of rebellion, lay clear enough away to the westward, with the sun glancing on the roofs, and the church steeples showing up above their neighbouring buildings; the city, could be distinctly made out. To get that place that then lay so temptingly beneath me, more blood was to be shed than possibly any other struggle in modern war had cost; and yet at that time the Federals were confident enough, and the expectation of soon being able to judge for themselves, gave a double interest to the inquiries as to what Richmond looked like. I could see the three camps of the Confederates round the place, one of them at Manchester, on the James River, but the distance (some 10 miles) was too great for me to distinguish more than the bare fact of there being three camps, and make the very roughest possible guess at their size. I could make out earthworks, thrown up apparently to bar the main approaches to Richmond, but of their character or strength I could judge little. Had the army got so near Richmond that the balloon could have ascended within three miles, a report of the nature of the defences could no doubt have been made, which would have cost a reconnaissance supported by a strong force to have obtained it in any other manner. I was present when the firing of a battery of artillery was directed from the balloon; the circumstances were as follows:—A picket of the enemy had established themselves among the trees on the banks of the Chickahominy, in a position near to the spot selected for a pontoon bridge; it became of importance to dislodge them, as it was fancied that they were strengthening their position, but owing to its being hid by some low banks, the battery that it was thought they were making, was invisible. The balloon being up and the signals preconcerted, the battery opened fire, the people from the car telling the artillerists which way their shot were dropping. The result of the operation was that the Confederates were driven from their cover; but I cannot say in that instance that I was impressed with the advantage of artillery fire directed from the air, though there are cases, no doubt, where a balloon might be similarly

and profitably employed. For instance it is not at all an uncommon artillery problem to breach an unseen revetment, when an occasional peep to see how the work was getting on, would be most welcome.

In this country some experiments on the subject of balloon reconnaisances have recently been carried out, and will, I believe, be continued next year. Up to the present time two ascents have been made, with a view of determining as a preliminary measure, first, the value of an elevated point of observation; and, secondly, whether the car of a balloon is capable of affording such a point. Simply with reference to the above, an ordinary balloon would do, provided a sufficiently still day were chosen; arrangements were therefore entered into with Mr. Coxwell for the use of his balloon, the Government finding the gas and necessary ropes.

The disposition of guy lines was the same as that which I have described as used by the Americans.

The first ascent was from Aldershott, on the day of the Royal review, which happened to be an exceptionably still one, with hardly a breath of air. Under these favourable circumstances an altitude of 1,200 feet was obtained, and the balloon was manipulated with ease; it took some quarter of an hour to haul the balloon down from its full height, and considerably less to raise it. Practice will, however, suggest both quicker and safer methods of managing this than that then used.

From 1,000 feet high the country lay mapped out beneath me for miles, though the haze prevented a very distant view. All notion of the relative height of ground was lost, indeed it was difficult to recognise as elevations the Hog's Back or Cæsar's Camp, on which latter place the troops were being reviewed. At that distance, then some three or four miles, the movement of the troops could be seen, and the tunes played by their bands distinctly heard, though from the ground neither the one or the other could be done.

During an ascent from the Arsenal, at Woolwich, the troops were sent out in different directions, so that if possible their positions might be made out from the balloon. This was not done, though I and my companion, Lieutenant Grover, examined the ground for an hour and a-half; it should be remembered, however, that the number of men in each division was small, and though we could not say where they were, we told where they were not, and the quantity of ground thus declared to be unoccupied was considerably more than could be seen from the top of any ordinary terrestial point of observation. Afterwards when we were about a mile high, having gone away free, and somewhere over the new docks at Blackwall, we clearly made out the troops assembled on Woolwich Common, preparatory to being dismissed to their barracks. The result of these two experiments appeared to me to show that the manipulation of balloons in the absence of wind was simple; that an altitude of 1,000 feet or less gave a sufficiently extended range of vision, and that to those who were accustomed to it, there was nothing in the car of a balloon that made it unsuitable as a point of observation.

I must however confess that reconnoitring from a balloon is not a pleasant occupation, in fact it is as unpleasant as the free ascent is

delightful, the least wind causes the huge machine to oscillate, and the motion, both in ascending and descending, given to the car by the unequal action of the ropes is disagreeable; the danger, too, is much more in a partial than in a free ascent, and much caution is necessary; the ropes cannot be made over strong, or they would be too weighty, and in the event of their breaking, the balloon, relieved suddenly of so great a weight, would shoot up like a sky-rocket, though a judicious use of the valve would no doubt prevent serious consequences. I have now done with the practice of reconnoitring by means of balloons, and shall make a few remarks on the apparatus necessary to effect that practice successfully.

To be applicable to military purposes, a balloon must possess the following qualifications :—1st. It should be readily available after the order for an ascent had been given, and it should be capable of being used in any place.

2nd. It should be capable of being used in any wind less than 15 miles an hour.

3rd. The height capable of attainment must be 1000 feet.

4th. The apparatus must be able to take up two people at least, with ballast and the necessary observing apparatus.

5th. The balloon must be so made that it can retain its gas for a reasonable time, viz., a fortnight, that is, that at the end of that time, its ascentional power must be such, that it be still capable of being used with a reduced weight.

On considering the above requirements, it appears to me that the Montgolfier, or heated air balloon, is at once excluded on account of its necessarily large size, which would make it unmanageable in any but the quietest weather; furthermore, the practical details of the heating apparatus, and danger attending its use, would be great, though perhaps not insuperable.

Gas remains therefore, and the choice lies between coal-gas and hydrogen, the advantages of the latter are its less specific gravity, which for present purposes is of great importance, as with a given lifting power, it presents a proportionably less area to be acted on by the wind, and the materials necessary for its production are more easily available, coal being a bulky article to transport, and otherwise not found usually with an army, while iron always exists in every camp, and the proportion of acid necessary to produce hydrogen gas from it is not very large.

Now a sphere with a diameter of 30′ has a cubical capacity of 14,000 feet.

1,000 cubic feet of air weighs 77 lbs., and, assuming the specific gravity of such hydrogen as would most likely be used at ·1, 1,000 cubic feet of hydrogen would weigh 7·7 lbs., and 1,000 cubic feet of coal-gas at ·3 = 23·1. We have thus

14,000 feet of air weighing	1,078 lbs.
14,000 feet of hydrogen weighing	108 lbs.
14,000 feet of coal-gas weighing	324 lbs.

which gives with hydrogen an ascertained power of 970 lbs., and with coal-gas 754 lbs.

This power has to lift as follows:—

Netting, car, and appurtenances.............	150
Silk bag	40
Two people	300
Three ropes, 1350′ long each	298
Ballast instruments and spare ascentional power	182
Total..........................	970 lbs.

With that weight the machine would, if filled with hydrogen, exactly float; a few pounds of ballast thrown out would cause it to rise.

Presuming that the best description of silk is used, the powers of a balloon to resist the dispersion of gas depend entirely on the varnish. I have mentioned that the American varnish answered the purpose; hence with an apparatus constructed as above, requirements No. 3, 4, and 5 are fulfilled; there remains Nos. 1 and 2. Now, as regards the first, that it should be capable of being used in any position and within a reasonable time after the receipt of an order, it is clear that this involves a portable gas apparatus. Hydrogen can be prepared in a variety of ways, nor does it require any apparatus unsuited to the rough work of a campaign; it can be made from zinc and sulphuric acid, iron and sulphuric acid, or iron and hydrochloric acid; it can, furthermore, be generated direct from water through the means of a voltaic battery, or by passing steam over red-hot iron.

The equations that show the first methods are:—

$$Zn + HOSO_3 = ZnO,SO_3 + H$$
$$Fe + HOSO_3 = FeO,SO_3 + H$$
$$Fe + H,Cl = FeCl + H.$$

By the first, 32·6 lbs. of zinc and 49 lbs. oil of vitriol, produce 200 feet of hydrogen, weight 1 lb.

By the second, the same is done by 28 lbs. of iron and 49 lbs. of vitriol.

By the third, by 28 lbs. of iron, and 36·5 lbs. of hydrochloric acid.

The three as regards material to produce a given amount of gas, being as:—

81·6 : 77 : 64·5.

Now the balloon requires 108 lbs. of hydrogen which, to produce, will necessitate the consumption of (taking the second as the most desirable process) 3,024 lbs. of iron, and 5,292 lbs. of vitriol. These figures are theoretical, and supposing the chemical action to be complete; (which in practice it would not be) it might be thought at first sight that hydrogen would be obtained at a less cost of material by the battery and water process; this would not, however, be the case, as is apparent when it is considered that for a given amount of gas a given quantity of zinc must be consumed, and whether it takes place within the generator or separately in the battery, matters nothing.

I think that very possibly the last process mentioned, that of

passing steam over iron, heated red-hot, may be found an advantageous one, but I believe its action is uncertain. The question of the production of hydrogen upon a large scale has never yet, so far as I know, been thoroughly experimented upon, because the necessity for it has not existed; but in the event of a balloon apparatus for war purposes being got up, it would receive due attention. I am inclined, however, to doubt whether, all things considered, any process will be found better than that with sulphuric acid and iron. The amount of acid required to be carried is not very serious, and iron in the shape of old shot, tires of wheels, &c., is plentiful with any army on active service. Still, to provide against contingencies, provision should be made for distilling gas from coal or wood, if circumstances should render it necessary to do so, the arrangements for which, when the material is forthcoming, would be simple enough. Now as to the last and most difficult requirement of all, viz., that the balloon should be capable of being used in any wind not exceeding 15 miles an hour. I quite agree that this is a *sine quâ non*, as the value of the apparatus would be materially impaired if it could only be of exceptional use; and so far as I know, no actual ascents have been made under these circumstances; indeed it would be useless and dangerous to attempt them without a specially constructed apparatus. I am speaking, of course, only of partial ascents. On both the days when I ascended in England, there was no perceptible wind on the earth further than a mere breath.

The mechanical condition of a balloon acted on by the wind, and kept to the ground by ropes, will be readily seen, and provided the current of air be constant, the difficulty would easily be got over. The ropes having taken a proportionate angle, the balloon would remain steady, but the fickleness of the wind makes this impossible, and on the pressure being taken off, the balloon would rise rapidly, to be as quickly thrown down again when the next gust came; in addition to which, the unequal action of the air on the silk would cause the balloon to struggle in such wise, as to make the car a very unpleasant mode of conveyance. In these matters there is a wide difference between theory and practice; theory says the ropes wont break, and if they do not, it is no more difficult to sit in the rocking car of a balloon than in a boat bobbing about on the waves; but practice says, there is a considerable difference; if any one doubts it, I can only say, let them try. I believe, however, that with properly constructed apparatus, partial ascents may be made, notwithstanding a tolerable strength of wind; but practice alone can prove this, and it would necessitate very careful experiments, advanced by degrees, as confidence was gained in the machine.

The force impelling the balloon downwards is in direct proportion to the area exposed for the wind to act upon, hence the size of the balloon and ropes should be as small as possible. With this view I would make the ropes of silk, when they would have equal strength with considerably less size. I am not clear about it, but I think that the shape of the balloon, too, might be altered with advantage, if a balloon were given a cylindrical shape and anchored head to wind, it would ride

somewhat like a ship in a stream-way. The advantage would be gained, however, at the expense of weight, as the sphere is the form of greatest capacity for a given surface; and further, of convenience, as there are considerable practical difficulties in the way of employing any but a globular shape, owing to the unequal strain on the netting, to which an elongated form would be subject. A more likely scheme to answer, though, perhaps at first sight somewhat wild, is to combine the principle of the kite with that of the balloon, and so make the untoward force of the wind correct itself.

Ballooning is yet quite in its infancy, and the first apparatus got up for military purposes would, doubtless, receive many alterations, which practice alone could suggest. Still, in my opinion, it is even as the art at present stands, capable of useful application, and if it failed to answer all expectations, the failure would not be great, nor the experiment costly.

In conclusion, though I fear I have already overstepped my time, I beg to offer a few remarks on the subject of aerial locomotion, which has always some interest, but which lately has attracted especial attention; Nadar having brought over a big balloon, for the avowed purpose of collecting funds, with which to carry out his theories of air travelling, which, so far as I understand them from his writings, are remarkably visionary.

Supposing a hook to be put in the sky, and a balloon anchored to it, the wind would press on that balloon with a force depending on its velocity, and the area of the balloon.

Now, it is found that the pressure of the air on the surface of one square foot is equal to ·005 lbs., and the pressure increases as the square of the velocity, because in a given time, with double the rate of motion, not only twice the number of particles strike, but they strike with twice the force, hence, at 15 miles per hour, the pressure would be 1·107 lbs.

Assuming the case of a balloon 30′ in diameter, which is the size of the one I have spoken of previously, the area will be 675 feet; hence, neglecting the difference which would be caused on the one side by the spherical shape of the balloon, and on the other by the resistance of its cordage, car, &c., the total pressure exerted by a wind, moving at a velocity of 15 miles per hour, would be 742·5 lbs. Now the effect is the same so far as the balloon is concerned; whether it be stationary and the wind moving, or the air stationary and the balloon moving, which latter is the case in point.

To impart, therefore, to the balloon, a motion of 15 miles per hour, would require a continual pressure of 742·5 lbs.; now, with the very lightest possible description of machinery, and with that machinery made in the lightest manner, it might be possible to construct an engine, which would give a duty equivalent to 742·5 lbs. pressure, and yet be within the weight which the balloon could lift, viz., 970 lbs.

At first sight, one is apt to jump at conclusions, and fancy that the thing is done, but the greatest difficulty is yet to come; the engine may be ready to give the power, but it is useless unless it has some fulcrum against which to act, and the loss of power is so great in

obtaining a fulcrum from the air alone, as practically to render available only a very small proportion of the power at command, the remainder is consumed in giving the necessary velocity to the screw, or other machinery used.

This will be readily understood, if we think over the following considerations: a corkscrew, working into a cork, at each revolution advances the distance between two threads; the screw of a steam-vessel does not, but for every ten turns advances, say only nine times the difference between the two threads, or what is the same thing, nine times the pitch of the screw, this difference being called the slip. Now this is owing to the mobility of the particles of water, which themselves are driven back, and the slip would increase with the facility of these particles for motion, or, in other words with the mobility of the fluid, air being infinitely more subtle than water, the slip, in place of being $\frac{1}{10}$th would be $\frac{9}{10}$ths (I am not, of course, now using figures, other than as illustrations, they are not correct), hence, of the force which was at command, 742 lbs., only 76 lbs. would be available to drive the balloon, which would correspond to a velocity of $1\frac{1}{2}$ miles per hour. The remainder, 666 lbs., being wasted in keeping the necessary machinery in motion.

That this reasoning is correct, that little toy very clearly shows, which is usually brought forward by enthusiastic aeronauts in support of their theories, I mean the flying top, which consists of light vanes fixed on a shaft, to which is given a rapid rotatory motion by means of a string. While the rotatory motion is sufficiently rapid, the top continues to rise; the vanes may not be very mathematically set, but I doubt whether any theoretical setting would alter the effect, and it will be seen that it takes a very strong pull, amounting to some pounds, to enable the machine to rise, though itself perhaps weighing an ounce or two, thus showing the amount of power wasted, so to speak, in obtaining a fulcrum.

Now, I deduce from this, that all theorists who hope to attain aerial locomotion by any combinations of steam-engines, or by altering the known appliances of vanes, screws, &c., come under the class of people who do not understand their subject. The real points to be obtained, to enable aerial locomotion to become a *fait accompli* are two, either, and principally, a new motive power must be discovered which shall combine a greater power with a less weight, or some means must be found of obtaining from the air a fulcrum as available as that furnished by water.

It will be seen, however, that even with the assumption I have made, I have got a speed of $1\frac{1}{2}$ miles per hour, which may be said to be something, and, I think, that very possibly even 10 or perhaps 12 miles per hour, might be got; but were that speed gained, beyond its curiosity and the credit attaching to the first step in a new science, nothing practical would have been obtained; for in the stillest day there are currents of air moving from 10 to 15 miles per hour, against which the balloon could barely hold its own, and from 20 to 25 miles I suspect to be the more ordinary rate of the air, some half mile from the surface of the earth.

If, however, even in such a wind, a rate of motion of 10 miles per hour could be given, it would render balloon journeys less hazardous, as at the end of one hour's travelling the aeronaut would have the power of changing his position within 10 miles on either side of a given spot.

Under existing circumstances all plans of doing without a balloon, and imitating the top, may be put on one side at once as visionary; from what I have shown above, a weight of 970lbs., gives an effective pressure to counterbalance it of only 76lbs.; hence the machine must fall. Toys have been made with springs which support themselves until the springs are run down, which toys lead people at first sight to think the thing is practical. They forget, however, that the little spring when wound up represents the whole force, which has been put into it extraneously, and in reality has nothing whatever to do with the real question, unless the power which wound up the springs were supported by the machine itself. If, even it were possible, the fearful danger, of making the safety of the apparatus, depend on the continuous action of a complicated piece of machinery, would be such that few but maniacs would make the experiment.

Evening Meeting.

Monday, February 15th, 1864.

Captain E. GARDINER FISHBOURNE, R.N., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between 2nd and 15th of February.

LIFE.

Morant, J. L. L., Lieut., Royal Engineers. 9*l*.

ANNUAL.

Prowse, J. F., Lieut. R.N. 1*l*.
Field, G. T., Major, R.A. 1*l*.
Graham, Allan, Captain, Renfrewshire Rifle Volunteers. 1*l*.
Davies, G. S., h.p. Capt. 6th Dra. Gds. 1*l*.
Bridges, W. W. S. Commander R.N. 1*l*.
Hunter, Edwd., Captain, 62nd Regt. 1*l*.
Laws, M. R. S., Ensign, 62nd Regt. 1*l*.
Marryat, J. H. Captain, R.N. 1*l*.
McNair, Fredk., Capt., R.A. Madras. 1*l*.
Napier, R. H. Lieut., R.N. 1*l*.

THE APPLICATION OF STEAM POWER TO THE WORKING OF HEAVY GUNS.

By H. D. Cunningham, Esq., R.N.

The question, "Can we continue to work our heavy guns by manual power?" is one which cannot fail to engage the serious attention of artillerists, and is the one which has brought me before you this evening. It is a subject, too, which in this practical age may possess a certain amount of interest to every one. My question is of course raised by the growing size and weight of ordnance. Already we have reached a gun of twelve tons in weight, and in Mr. Reed's new ship, the Bellerophon, we are promised that a part of her armament shall consist of 600-pounders, which must far exceed the 12-ton gun in weight and proportions. And shall we stop here? There is full reason to believe we shall not. When we have our 600-pounders we

shall then look forward to the 800-pounders, and so on to 1000-pounders. And heaven only knows where we shall then stop. And then will indeed apply my question, if it be not already applicable to guns already in use, "Can we continue to work our heavy guns by manual labour?" Now this doubt has not been raised in my own mind alone. It is one that has come to me in various shapes from many intelligent and far-thinking officers, and is generally accompanied with the admission, with reference to the subject of my paper, viz., the application of steam-power to assist in the working of heavy guns, "We must come to something of the kind at last."

The question is not, as it were, a gunnery one; that is, it does not refer to the science of gunnery; for if it had done so, I would not have presumed to go into it, not being a practical artilleryman. No; it is purely a mechanical question; and it is as a mechanic that I deal with it.

For some time past I have been under the strongest impression that we were drifting into such a state of things, that more extended power must be applied to the mechanical part of the working of great guns. Watching the rapid growth in the sizes and weight of ordnance during the past two years, it appeared to me to be unreasonable to suppose that ordinary manual power could remain as the prime motor for working them, and that the arms of flesh and bone must give way to the iron arms and sinews of the mighty steam-engine. I own, my views have often been shaken and discouraged by remarks of experienced gunnery officers, that come what change there may, in the weight of guns, they must be worked on board ship by seamen; that the number of men must exist in the crew of a fighting-ship, and what may be required in power can be obtained in numbers of men. But looking back on the experience of the past thirty years, and viewing the stubborn fact how much animal power has yielded, right and left, to steam power, then I believe that many here will agree with me, that measuring such opinions by the past, they can scarcely be held to be tenable.

I will admit personally to a large amount of conservative feeling on this subject, dear as it must be to every Englishman, and would that we had remained in that good old state of things, when the weight of our ordnance was such that the success of an action depended on the thews and sinews of our gallant seamen; when a frigate with 56 cwt. 32's on her main deck was considered to be a heavy ship; when we had no costly steam navy to draw the string of taxation so tightly round our throats in the shape of income-tax; no iron-clad monsters to mar the seaman's pleasure in the contemplation of his ship, which in good old times gone by, was poetically described as his ideal of beauty, next or even before his mistress. But those days are gone for ever; that iron monster of revolution, the steam-engine, has changed all these things. If it had not been for his mighty power we should have had no iron-clad ships; without iron-clad ships we should have had no mammoth guns. But the crustaceous sea-monster once created, suggested a new field for the exercise of mechanical and gunnery science. Those ironsides which were at first vauntingly pointed out as

defying the effect of shot and shell, and within whose casemates the crew were to fight unharmed, unhurt, must be pierced. An impulse was thus given to gunnery science; the talent of our engineers, and the resources of our iron establishments, were roused to the work. Gun after gun, shot after shot, have, since the creation of the iron-clad ships, been rapidly progressing upwards, in size, weight, and tremendous effect, until, as before remarked, we have now arrived at guns of 12 tons weight actually in use; and have every prospect in a few months more, of having ships afloat, armed with 600-pounders! But we will now consider some leading features of the subject of the possibility of continuing to work modern guns by manual power, upon the argument that power to any extent may be obtained by numbers of men. Now, every one who is familiar with the operation of working broadside guns on board ships,—for it must be understood, it is with reference to this arrangement of armament, I have hitherto directed my remarks,—that the space about and in the immediate neighbourhood of the gun is very limited, and especially so in the case of guns of the huge size which we are supposed to be now treating of. It will be also readily admitted, that a man to exercise the full power of his strength, must have a certain space allotted to him; he must place his body in a suitable attitude to call into play the full energy of his muscles, and unless he has the space for this purpose, he cannot use the full amount of his strength. Consequently, when men are crowded together, which they necessarily must be, to make up the required amount of manual power for working one of the modern heavy guns, a very large amount of their energy is diminished, and the full amount of power expected to be derived from a given number of men will surely not be arrived at. The amount of hauling power amongst men crowded together will be seriously affected by the motion of the ship. Every seaman knows how much loss of this power there is, when the ship is knocking about at sea, and it is easy to account for it; much of the muscular energy of the man is applied to keeping his balance, and hence he cannot use the same amount of strength as when standing firmly on a steady level. I hold, then, that the principle of making up power by numbers for working heavy guns, is certainly limited in its application. Beyond a certain number of men, the extra number that may be applied will tend to diminish the muscular power of the remainder, and when dealing with the tremendous weights that are promised in the shape of future guns, it will be difficult to make up the required power by number of seamen. On Thursday last I had the pleasure of witnessing the exercise of one of the 300-prs., a 12-ton gun, on board the "Excellent," or rather "Illustrious," and certainly the facility with which the gun was moved about much exceeded my expectation, and went far to negative the impression which I had on the subject, when the introduction of such guns on board ship was only talked of. The number of men at present forming the crew of the gun is twenty-one; and ten men on each side ran the gun out. I did not see the gun run in by manual labour, as it was firing exercise, and so the gun came in by itself, but I was given to understand that it could be dragged in by the same amount of manual

power. The mechanical appliances for running the guns out consist of a treble block and double block, of course on each side. Now, the guns on board the "Illustrious" can certainly be only recognised as battery guns, that is, the deck upon which they work is always on a level. The real practical trial of working such guns has yet to come. The question, how far these ponderous masses can be worked up varying gradients, and subjected to all the forces incidental to heavy guns at sea, has yet to be seen;* and it must be fairly doubted if twenty-one men, or half as many again, will be able to control those ponderous guns at sea. Some time ago, when I was collecting information on the subject, I was informed by officers in the "Resistance," that although the standing crew of the Armstrong 110-pr. was seventeen men, they always had twenty-one to work it at sea. One word more on this point: it has often been remarked to me by officers, that they always dreaded casting loose their 68-prs. at sea, and were always delighted when the guns were again secured. If then this anxiety existed in regard to guns of between 4 or 5 tons in weight, how great it must be, or rather will be, when dealing with guns three times heavier, with probably all the embarrassing accompaniments of wet, slippery decks, a consideration which must be added to those already advanced as regards the impossibility of men putting forth their full strength under certain conditions at sea, and which I cannot help believing, must impress many with the desirableness of applying such a power to work heavy guns, as will not be affected by circumstances of this description.

On Thursday last, as I contemplated the captain of the gun pointing and directing his gun, the impression came forcibly upon me that in that individual was vested the power, and, if I may use the expression, the intelligence, of the gun. The animal power on each side of the gun simply represented power put at his command to move the gun in the direction he required, and to execute the other purely mechanical parts of the working of the gun, but had little if any sympathy in the intelligent part of the operation. Obedient and well-trained as the men were, still the wishes of the master-mind were not carried out with that prompt mechanical action that it appears to me the conditions of modern gunnery require; and I must also add, with that *smoothness* that could be, were mechanical power used instead of animal power. As the command was given,—muzzle left or muzzle right, as the case might be,—the result did not immediately follow on the expressed wish. The men had, as it were, to gather up their strength before they applied it; and even when they did begin to pull, it was some little time (but, mind you, only very little, but still a little loss of time) before they could obtain the necessary harmony of action to apply their strength with the desired effect. I noticed, too, that this spasmodic application of power, if I may use such an expression, sometimes resulted in the slide being dragged beyond the desired

* The mean of the number of rolls per minute of the French iron-clad squadron of seven ships in fine weather, with a long slow swell, has been stated to have been six, and the extent in degrees 11°.—H. D. C.

point, and the reciprocating force on the other side had then to be put into action to drag the slide back. Now, reflecting upon these observations, it appeared to me that they were grave defects in the mode of working guns, and altogether inconsistent with the requirement of modern gunnery. It is more than probable that a considerable portion of future sea-fights or battery engagements (which God forbid, at the same time, that such should ever occur) will be under conditions of one or both of the engaging bodies being in motion, and in rapid motion too. The success, then, of the discharge of a gun, will depend upon the quick and steady manner it can follow a passing object. It will not be as in days gone by, load and fire, load and fire, and hit where or what you can, or nothing at all, so long as you blaze away, —a mode of fight which, ridiculous as it may appear, I believe some of our noblest actions were won by, but it will not be so now *every one of our modern costly bullets must have its mission surely selected for it before it leaves the cannon's mouth.* Then, I maintain, that the efficiency of our present elegant and beautiful arms of precision, for such they must be styled, must be impaired by the palpably defective means for the training of them. I repeat, those 300-pounders on board the "Illustrious" are truly magnificent guns, and proud as a nation we ought to be at having them, and thankful to those talented engineers and all concerned, who have provided us with such fine guns for the protection of our shores, and British honour and commerce over the wide wide world And, I repeat, when I contemplated this huge cannon obeying, almost with intelligence, the biddings of its master-mind, the captain, belching forth, too, its iron missiles, and when done, standing quietly and peaceably to have its iron stomach replenished with more (I must be pardoned for using the expression) of its satanic food, then there was only one thing which appeared wanting, and that was, that that master-mind, the governing spirit of the gun, should have had more complete mechanical arrangements at his command to bring that magnificent instrument more sensibly under his instant will and control, and which, I believe, can only be provided by the application of steam power.

I believe and hope that Captain Cooper Key will make every allowance, if in my mechanical ardour I am uttering words that may *probably* be in contradiction to his views on the subject. I use the word "*probably*" because, although I have had the pleasure of communicating with him several times lately, I cannot say that I know how far he is disposed to go with me in this matter. I have, however, observed that Captain Cooper Key is a true mechanic at heart, and consequently he must not only sympathize in my views, but must also admit that mechanical operations, whatever they may be, must be executed with greater precision by mechanical power than by animal power.

And now, to return to another consideration of the theory, that the power for working heavy guns can be made up by numbers of men. On board the "Excellent" I saw a piece of $5\frac{1}{2}$-inch armour-plate that had been pierced through and through by a steel shot, that would have carried death and destruction with it on the other side. What, then, is the reflection that is created by this fact? Is it not this most unpleasant

truth, that in spite of all our vast expenditure of money to render ships impervious to shot, bullets and guns are now provided to pierce the thickest armour-plate yet laid upon a ship's side; I am not going into the question of armour-backings and such like, but this much I would say, that if we are to conclude that ships' sides can be penetrated, and that men within their casemates will be liable to be shot down, does it not suggest the question whether it will not be desirable to study in every possible manner to fight the guns of a ship with the fewest possible number of men exposed. And surely this is a sound theory. Is it not the perfection of good generalship to do as much harm as possible to your enemy, with the least possible hurt to yourself? Now I hold that the grouping together of large numbers of men in the neighbourhood of a gun, exposed as they would be not only to the effect of solid shot and its tremendous splinter results, but also to shell entering the port, is a thing to be avoided. Imagine, if we can, the destruction which such missiles would deal amongst a cluster of men, and the helpless condition of the gun when deprived of a large share of its working power, which with heavy guns, would be inevitably felt more sensibly in proportion, than with lighter guns. Imagine, too, the exhausted condition which the remaining men would soon be reduced to, from the extra work imposed upon them. On reviewing the picture, let us imagine what the effect of a shell entering the port would be. I scarcely dare permit myself to hint at anything like a panic occurring amongst British seamen, yet the effect of a modern shell between decks of a ship must be something so terrific, that you might almost excuse the strongest nerves suffering under such a trial. Now the iron men which I propose to substitute for flesh and blood will be insensible to all this. Through shot and shell, through carnage and horrors, through noise and confusion, provided their vital parts are not touched, which is not possible, unmoved they will surely and steadily perform their part of the battle. The provision of a few steady and tried veterans to load and direct the guns on the fighting-deck (it must be understood that I provide sundry mechanical helps to assist in loading) will be all the men that will be exposed. All the other portion of the work, as I shall presently explain to you, will be, or rather can be, performed under cover on the deck below, not only greatly removed from danger, but from also the witnessing of the probable tremendous effects of modern gunnery science. The amount of labour required of the seamen will be very small; the really hard work will be performed by the iron men, who can *feel no fatigue, be the action ever so long.* Then let me put it to you, would not a ship, with such provision for fighting, be immeasurably stronger and capable of enduring a lengthened action, than the ship whose powers of endurance depend on flesh and blood.

As I have before observed, my remarks have been hitherto directed to guns worked on broadsides. I have, however, as you will see by-and-by, arranged for an application of steam-power to the working of guns in revolving turrets or cupolas. Many of you may remember that Captain Coles alluded to this in his lecture last year, and said that he knew I was maturing a plan for applying steam-power to work

guns in his cupolas, which he considered would be an advantage. Now in this I have succeeded even beyond what I anticipated, for not only has the mere moving of the gun in and out been accomplished, but other advantages have been obtained which are very important indeed.

At this stage of my paper, I would call attention to the life-preserving character of my designs for superseding manual power by steam power for fighting ships. I should be untrue to the colours under which I have already fought a mechanical battle for this object, and which I trust, by God's help, has been the means of saving many many lives. If I did not admit this consideration as an important element in my present undertaking, it is undoubtedly one eminently calculated to preserve human life. I have no desire to reduce the crews of our ships of war, although with the extended mechanical power for fighting guns which I provide, we cannot hide our eyes to the fact that my inventions tend that way, and may be highly interesting to political economists for that reason, still the power afforded for working the guns with so few men exposed to danger is a feature in my invention which claims humane consideration, and, let us believe, must be acceptable on that account. Those dark ages are I hope and trust, gone for ever when the extent of a triumph in arms was measured by the length of the "butcher's bill." Christian men and gentlemen now enter into the dread science of war with different feelings, and therefore if war must be, if the arbitrament of the sword must be resorted to, then let us study to diminish as much as we can the sufferings inseparable from it.

But now to description.

It is about two years ago that I first entertained the idea of applying steam power to the movement of heavy guns. At starting, the matter appeared full of difficulties. In the first place, it seemed impossible to obtain the necessary direction of forces without resort to complicated machinery. Again, it appeared very undesirable to introduce any remarkable change in the general arrangements of guns, such as their mounting, &c. Whatever I did, too, it was highly desirable not to reduce the fighting organisation too much to a machine; that at least something should be left for the crew to do. Indeed the consideration of the matter resolved itself into the following points:—

First. That if possible everything in the shape of machinery about the gun-carriage should be avoided.

Secondly. That the means should be such as to come within the comprehension of seamen to handle, without the necessity of having an engineer to every gun.

Thirdly. That the motive means should be of the simplest possible character, and placed so low down in the ship as to be out of the way of shot.

Fourthly. That the form of carriage, &c., should be such as to enable the gun to be worked by ordinary means, should any failure arise in the steam power.

Now I think you will agree with me after I have described my plan to you, that these conditions have been very closely adhered to.

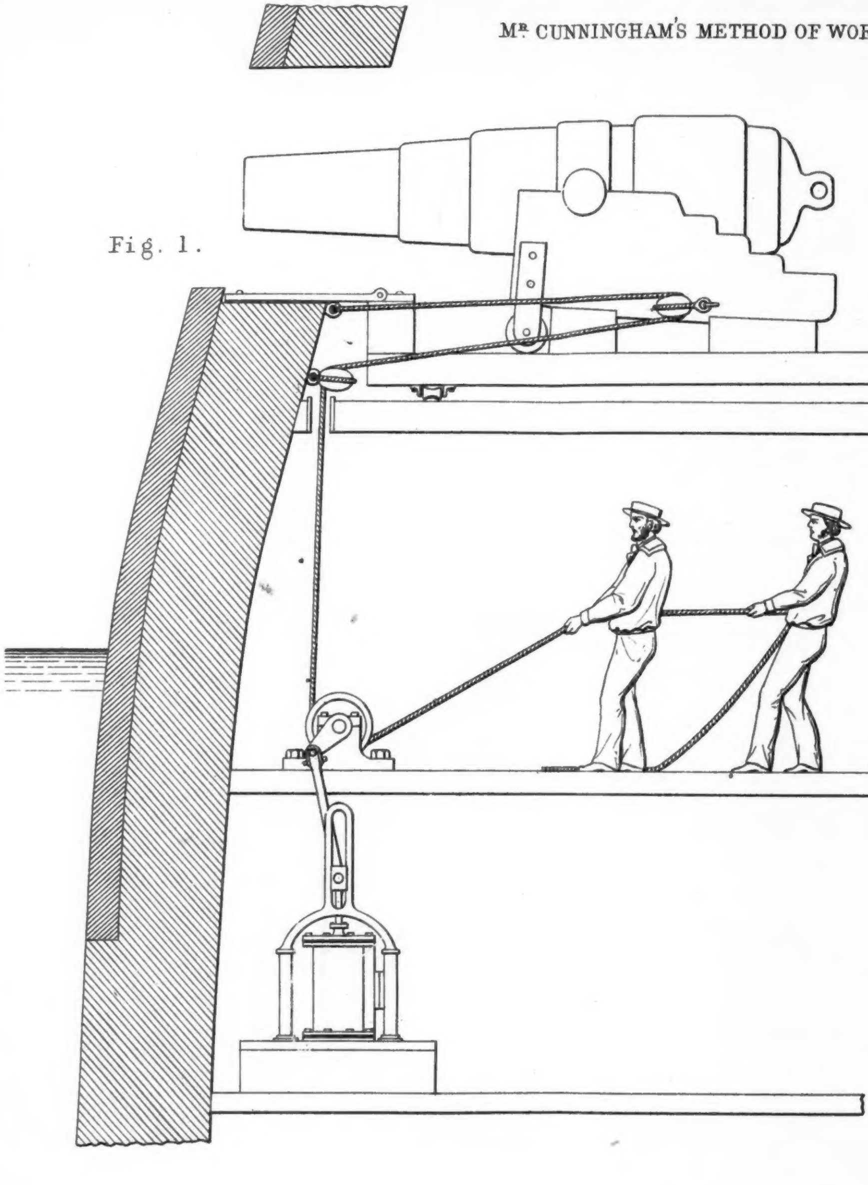
Two forms of applying the steam had to be considered. One with reference to guns worked in broadsides, the other as regards guns worked in turrets or cupolas.

As regards broadside guns, two motions had to be arrived at. One a reciprocating rectilinear motion, for the running in and out of the gun, another a circular horizontal motion for the training of the gun. In regard to the turret, this last motion was provided for, and the running in and out motion alone had to be produced.

Now, I can assure you, when I first took the matter in hand, I was sorely puzzled how I could obtain the different motions for the broadside guns, without entering into cog machinery and other mechanical complications, and thus depart from the condition of simplicity which I believed could alone give practical value to any arrangement of the kind. Various were my plans, and various were my failures, until I conceived the idea of going into the work on the millwright principle of shafting; I determined to lay shafts along the deck, underneath the guns; upon these shafts, have drums or windlasses; lead the various tackles for running the gun in and out and training, down through the deck, to and round these drums or windlasses; and then I had the whole mechanical organisation complete for working guns by steam, and possessed, too, of so much simplicity, as to come within the comprehension and ability of seamen at once to put into operation; we will now refer to the diagrams. Plate VI, Fig. 1 shows, as you will see, a side view of a gun, ship's side and decks. The gun represents a 300-pr., or 12 ton gun, drawn to scale. I scarcely need the aid of distinguishing letters to denote the various arrangements and appliances, as I think they cannot fail to be clearly understood by practical seamen; I have only shown one tackle, as that appears sufficient to illustrate the mechanical arrangement of the whole. The gun is represented as being run out. The side tackle, it will be seen, leads through the block in the ship's side in the ordinary way, but instead of returning inwards to be pulled upon by men; it goes through the deck, to and round a windlass on the deck below; another view of which appears in Fig. 2, showing also the two windlasses or drums which would be required to work a gun, and the necessary number of ropes for the operation. In this Plate, too, an outline of an engine appears placed on the orlop, and, of course, underneath the water, and out of the way of shot, which engine communicates motion to the strap above; this also is put underneath the water line. Now, the manner of operating on this arrangement is this—so long as the ropes round the windlasses are slack, or at least no great strain upon them, the windlasses revolve within them without affecting the tackles, but directly the end of any of the ropes is pulled upon, the windlass instantly nips the rope so pulled upon, which is dragged downwards, and consequently draws the gun in the direction of the rope so dragged upon; for instance, if it be wished to run the gun out, the end of the running-out tackle is pulled upon by one or two men, and the gun instantly follows it to the port. Again, if it be wished to train the muzzle left, the train tackle, or rope representing it on the right side of the carriage, is pulled upon, when

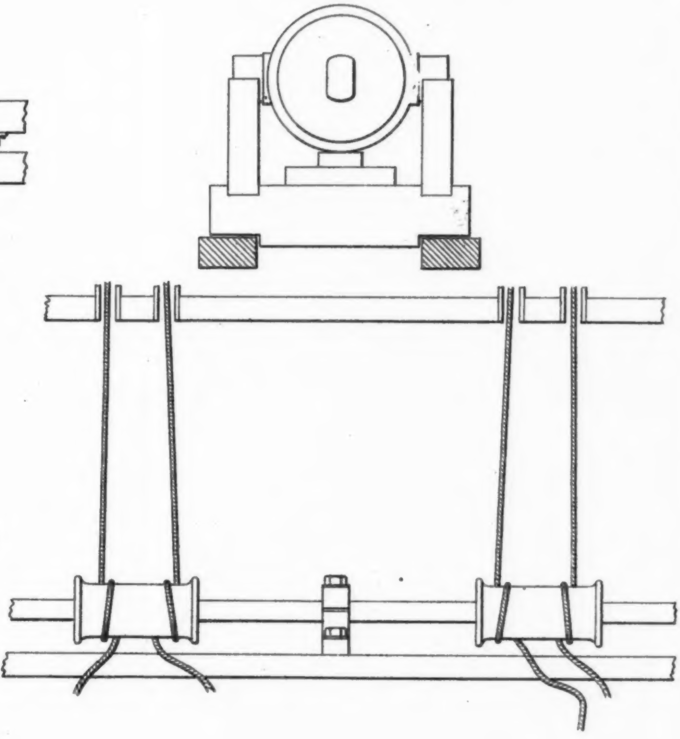
Mr CUNNINGHAM'S METHOD OF WOR

Fig. 1.



D OF WORKING BROADSIDE GUNS BY STEAM POWER.

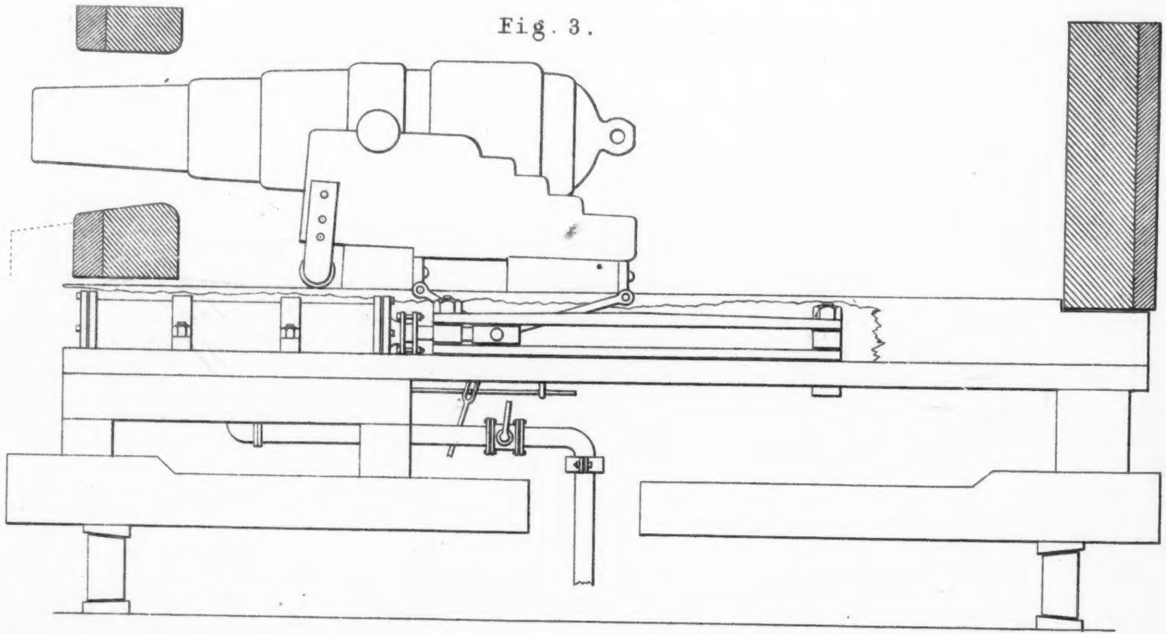
Fig. 2.



J R Jobbins

MR. CUNNINGHAM'S METHOD OF WORKING TURRET OR CUPOLA GUNS BY STEAM.

Fig. 3.



J.R.Jobbins.

the gun is trained accordingly. In the drawing, the ropes are represented as working the gun from the deck below, but by leading them up again through the deck and over blocks, the ropes can be operated upon on the gun deck. My impression, however, is very strong in favour of working the guns as much as possible from the deck below, so as to remove as many men as possible from the fighting deck, for the reasons before given. In the model which I am now about to show you, it will be seen that I lead the train tackles to the fighting deck, but keep the running in-and-out ones below. In these days of telegraphy there can be little doubt but that communication can be arranged between the two decks. In conclusion of my description of this form of my invention, I would again refer to the prospect of its being impossible to render a ship's side invulnerable to shot. If this should be the case, then are we not in the same position that we were in the good old days of wooden walls, and, probably, worse; and may it not become a question, if it will not be better to return to them again? Adopt the measures I now propose, to expose as few men as possible to danger on the fighting deck, and let the shot go slap through the ship.

And now we come to the cupola. In this form of mounting and working guns, the application of steam power in the manner proposed by me, and which I am about to describe, affords great security to the guns, and in many ways brings the gun under such complete control as to encourage the firm belief that a gun could, under these conditions, be worked in the heaviest weather. Referring to Plate VII, Fig. 3, you will, I have no doubt, be able to follow me without distinguishing letters, and see that between the slides I place a steam cylinder firmly secured to a plate and bed-piece. The end of the piston-rod works between and in strong guide bars, firmly bolted down to the bed-plate, over and upon which lay the sides of the slides, the ends of which go under the structural part of the turret. I am particular in calling your attention to this, as I want to show the security which is given to the bed-plate by this arrangement. Now, from the end of the piston rod are two connecting rods, the respective ends of which are bolted to plates on the fore and rear chocks of the carriage. The steam pipe I lead up through the hollow axis of the cupola, and the throttle valve and D valve levers are conveniently placed for the working engineer to have command over both. In the diagram, for the sake of showing their existence distinctly, I have represented them vertically, but they probably would not be placed in that position, but horizontally, as in the model. Now, here we have the material arrangement of my plan for applying steam power to turret guns. The practical working needs but slight explanation, for it will be readily understood that by the alternate action of the valve lever the gun is moved backwards and forwards on the slide, as I now practically exhibit on this model. You will also perceive that when the gun has been run out by the pressure of the steam, unless the valves are reversed it will remain out; and, again, should it be in for loading, when, of course, it will be desirable to keep it in for that purpose, so long as the steam is kept on at the other side of the piston,

the gun will remain in. I also contemplate employing the steam as a cushion to check the recoil. I cannot see at present any practical difficulty to it; but even if that should not be found desirable, I have provided a more powerful brake, or compresser, which will serve that purpose. Should, therefore, the steam not be used to check the gun at the moment of firing, the steam will be cut off, and the gun will then run in in the ordinary way, the steam remaining in the cylinder, acting most beneficially in checking recoil, and it may probably prove sufficient for the purpose. I further contemplate that the movement of the gun will be so entirely and completely under control that instead of using the sponge and rammer in the ordinary way, the gun shall be made to sponge and ram itself. I will now call your attention to the points of security and power of action which I obtain in this form of my application of steam power to working guns. You will observe, in the first place, that in consequence of the gun carriage being tied down to the slides by the two connecting rods, the secure way in which the guide bars are bolted to the bed-plate, the impossibility of the bed-plate lifting on account of the slides with the gun on the top of them keeping them down, and then the turret itself keeping the slides down, that be the motion in the ship ever so violent, yea, let the ship be even almost reversed, the carriage cannot be disengaged from the slides. Again, the power of working the gun in the heaviest weather and most turbulent sea, would be almost unlimited, with a 15-inch cylinder, and steam, say 45lbs., we may estimate that a prime pushing power of about 3 tons would be obtained, which I think we may calculate would be sufficient to start the gun and drive it up a considerable inclination. Thus then in the heaviest weather, so long as the steam were up, which could be accomplished quickly, as it would not require a very large steam generator, the guns could be securely and surely worked.

And now, before closing, I would remark that soon after I had taken up the consideration of this subject, I discovered that the question did not rest with the mere moving the guns about, that the increased weight of projectiles, and other considerations regarding the growth in the size of ordnance pointed out the necessity of a reorganization of all mechanical armaments for working guns, from the magazine upwards. I was irresistibly drawn into this; one thing led to another, until I could cover the table with models of designs for the service of shot and powder, training of guns, checking the recoil of guns, means for lowering and raising the level of guns in cupolas, and many other details relating thereto, all of which are now officially under the consideration of Captain Cooper Key, and all, if not most of them, must be adopted in some shape or an other. It would have been impossible, however, to have included them in the present paper. I have, therefore, strictly confined myself to the text of it, viz., "the application of steam power to the working of heavy guns."

Rear-Admiral Halsted: I should like to ask Mr. Cunningham one question. I do not know whether he has included the working of the cupola.

Mr. Cunningham: No; I have confined myself simply to the question of working guns.

Admiral HALSTED: I hope you will give your attention to that.

Mr. CUNNINGHAM: I have done so.

Admiral HALSTED: Because it is a thing still more inevitable than the other.

Mr. CUNNINGHAM: I have done so; but this evening I have confined myself simply to the working of the gun. I think I have also made a great improvement in the working of the cupola.

Admiral HALSTED: I think you are hitting the right nail on the head very hard, and driving it very considerably home, no doubt, whether for broadside guns, or cupola guns; but there is the further consideration, which I have referred to. It is quite a consideration as to whether the cupola vessel of the Danes, which they have had since June last, the double cupola vessel, which probably is now very hard at work at Alsen, whether she should not have been fitted with steam to work her cupolas; it will inevitably come to that.

Mr. CUNNINGHAM: Capt. Coles reports so favourably upon the manner in which he can move the turrets in the "Royal Sovereign," with manual power, that although I had provided a simple arrangement for moving the turrets, the result of his cog-machinery seems to be so very good, that I have not gone on with mine.

Admiral HALSTED: Already I think the working of the gun in the cupola gives immense power to it. I may mention that he (Capt. Coles) ultimately contemplates employing steam; but at present he is content with putting the thing forth on the original system, by employing manual labour. I am sure you will give all the assistance you can, because I think that the cupola is the true ship of the future.

Capt. CHADS, R.N.: You will keep the shaft shown in Fig. 2, and which works under the gun, along the deck, going throughout the action; you hold on, I suppose, when you want to work it?

Mr. CUNNINGHAM: Yes; and that shaft is always going round throughout the action.

Capt. CHADS: Does one engine work the whole of the broadside guns, or have you a number of small donkey-engines?

Mr. CUNNINGHAM: Supposing we are dealing with vessels with eight guns on each side, we should have two engines, one at each end of the battery, or two engines amid-ships, connected with each other by a shaft.

Capt. CHADS: Do all your tackles go to one shaft, your side tackle and your tackle for training the gun?

Mr. CUNNINGHAM: Yes.

Capt. CHADS. That may be ingenious in the model, but I do not see how it can work in practice. I do not see how you could take all your tackles to one shaft.

Mr. CUNNINGHAM here worked the model, to show the possibility of its being done.

Capt. CHADS: How many tackles have you at work?

Mr. CUNNINGHAM: I propose to take the present form of carriage, which I fancy will be the one adopted in heavy guns. In this form of carriage you have two fulcri for your two tackles. I am obliged to give new names for them. I call them my running-in tackle, and my running-out tackle. I avail myself of this carriage to obtain means for working one tackle for running in, and one for running out.

Capt. CHADS: Do all of those four go to one shaft, and do all four remain on that one shaft all the time?

Mr. CUNNINGHAM: Yes; but you will understand when the falls are slack, the windlasses revolve inside the rope without affecting the tackles. As you see I am turning this windlass round, it does not affect the tackle at all; I have one or more men to each fall, and I call them the running-in and running-out tackle.

Major LEAHY, R.E.: You say you might have one or more men to each fall; supposing, however, that in action, the gun was being run up, and that by accident, both training falls were worked at the same time, would not that create confusion?

Mr. CUNNINGHAM: I think the result of that would be, that the one who holds on the best, would drag the falls out of the other man's hand.

Major LEAHY: Talking of the gun being under the immediate control of the captain, I doubt whether the men working down below would really be under the immediate control of the captain during the heat of an action?

Mr. CUNNINGHAM: Some system of communication must be established between the two decks; and as I mentioned in my paper, I have no doubt in these days that some system will be devised. I have already a plan for communicating with the two decks, which I think might easily be adopted, because, in communicating with the engine-room now, there is no difficulty at all.

Major LEAHY: In fighting the gun, you must remember, that there is a great deal of excitement.

Mr. CUNNINGHAM: If you found any difficulty at all, you could bring the whole of your tackle on the upper deck, and have the whole of your men under the immediate control of the captain.

Major LEAHY: The next point I wish to come to is this, you must have a certain number of men on the fighting-deck to load the gun. A six hundred-pounder would require a certain number of men to load it; I do not know how many.

Mr. CUNNINGHAM: I do not wish to cut down the number very close, but I calculate that the twelve-ton broadside gun would have six men on the fighting deck. It would not take more, and that would be a great reduction; for that gun will require, at least, thirty men to work her at sea. And, of course, if you can take 24 men away, it would be an immense gain.

Major LEAHY: Quite so; but you must have at least six to load and ram home.

Mr. CUNNINGHAM: You will understand that I provide great assistance for loading the gun in the plan which I have before alluded to, and for conveying the projectile to the mouth of the gun. I have provided plans for that, and also for the conveyance of the powder. The weight of the powder is not, however, so important as the projectile, which is certainly the most important thing, because it is immensely heavy. With regard to the spherical shot, two men can manage that easily enough. I say easily enough, but they are obliged to land the shot on the plate in front of the gun, and it requires a great effort to do it, but still it is done, but with the elongated shot it is quite another affair.

Major LEAHY: It appears to me that you must have a certain number of men on the fighting deck to load the gun, and that the gun will be more under the control of the captain by having the men to work the tackle on the same deck. I apprehend there will be a difficulty in getting it under complete control by having the men to work it on the under deck.

Mr. CUNNINGHAM: You can lead the tackle up through this deck by simply having another block.

Major LEAHY: Have you thought of applying the system to a fixed battery?

Mr. CUNNINGHAM: Yes; the only difficulty is, that in an extended battery you will require such long shafting. I fancy the system is more applicable to ships than it is to batteries, unless in the case of such compact forts as those building at Spithead, where the guns will be close together; and then I dare say the shafting might easily be carried through.

Major LEAHY: I do not think it should be assumed that we shall not improve the carriage. I think that it is very desirable in an arrangement of this kind, when you commence to apply machinery to a gun, to consider whether you cannot so apply it as to pivot the gun at the muzzle. Of course, in using these large guns, if you can apply mechanical power so as to give elevation and depression of the gun as well as training, it will be a great point gained.

Mr. CUNNINGHAM: In the 12-ton guns on board the "Excellent" there is a beautiful plan for elevating and depressing. I had myself devised a plan, but I have given it up in favour of that plan. It consists of a rachet working inside the brackets of the carriage. It is very quick in its motion; one man can elevate and depress the gun with the greatest ease. There has been one thing adopted with these heavy guns which assists the operation; they are poised better than the old guns, and there is not so much preponderance of weight at the breech.

Major LEAHY: So long as you pivot from the trunnion instead of from the muzzle, you must provide a larger port than you would otherwise require; if you could pivot the gun from the muzzle you could reduce the size of the port. It is a matter that has been under the consideration of some persons, and plans have been proposed for pivotting guns at the muzzle.

Capt. JASPER SELWYN, R.N.: I have the greatest pleasure in rising to give, as the first thing, a due tribute of praise to Mr. Cunningham, and to say that I am sure it is the conviction of every one who has been listening to him, that he has not fallen from the fame he has so justly acquired in other directions of saving labour. He has shown us a most ingenious and practical mode of doing that by simple machinery which it had been often supposed could only be effected by complicated machinery. It is true that there still remains the objection, which I am sure he won't underrate, that, if shot come in, no matter how simple the machinery, yet it is liable to destruction; therefore it would not be wise to abandon the armour when we increase the delicacy of our machinery, or, on the other hand, to rely entirely on any machinery. In a great measure this has been attended to here. I regard it as one of its chief excellencies that you can apply the ordinary tackle to these guns in case of the mechanical appliances, which he has explained to us, being destroyed by a shell or spherical shot, which we are beginning to learn make no more account of five or six inches of armour-plate than the old cast-iron shot did of the wooden ships. Mr. Bessemer has promised us nine inches of armour-plate, if we will only consent to use steel for our ships instead of iron. Therefore I think Mr. Cunningham may still continue to believe in the efficacy of armour-plates to keep out shot. That he should economise the risk to life is a most delightful circumstance to every Christian. It has been done by him to a very great extent in the reefing of sails aloft; he is now proceeding to carry out the system below. I have a few words, however, to say about its adaptation to the cupola. In the first place, I say that the steam-pipe must necessarily have a moveable joint. It must come up through the central shaft of the cupola, and as the cupola is trained round, you will see the steam-pipe must necessarily move round in its gland. Now, the working of the cupola, however it may be made, is yet a serious question; and it is open to doubt, whether that joint could be efficiently kept water-tight during the roll of the vessel and the working backwards and forwards of the heavy gun. I am sure, however, that with Mr. Cunningham's mechanical skill, he will not leave that point unattended to. The next thing is with respect to the cupola. I do not think, though some of my seniors have praised it, that it is *the thing* of the future, simply for the reason that you must fire through your own decks in many instances. If your ship is heeling, there is no possibility of firing on a level from a large ship with your cupola in the centre without firing through your own deck. Secondly, the cupola adopts and insists upon the principle of putting a very few eggs, and those of a large size, into one basket. It cannot be cheap to make a vessel of 6,000 tons to carry six guns, however big they are. You may put the same number of guns into a smaller vessel and adopt those appliances, as I have no doubt will be adopted, and you will not require so large an expenditure. I think that the public would be very ill-pleased to hear that half a million of money had been lost in running after a "Monitor" over shoals on the American coast. The method of working guns by *communication*, of which Mr. Cunningham has spoken, seems to me to present one of its greatest difficulties, if we leave out the consideration of gun-cotton. If we get rid of the smoke, as gun-cotton promises to do for us, then pointing the gun becomes possible which it is not now; for the finest sights, and the most careful man, and the most accurate pointing are all thrown away when once you get into broadside action. If we get gun-cotton, then pointing may come into play, and have its due weight, and in that case accurate and rapid communication between the captain of the gun, whom Mr. Cunningham has fitly said is the intelligence of the gun, and his subordinates is absolutely necessary. Electricity would be scarcely attainable for such a purpose. It is true that the captain of the ship may communicate intelligence by means of electricity, as has been beautifully done by Mr. Gisborne; but I should be sorry to trust to that beyond a certain limit, arising from that of which I have been speaking—the delicacy of the machinery. It applies equally to the electric batteries; because as you are all aware the wires may be very easily severed by splinters, and your communication then comes to a stand-still. Therefore, you cannot entirely trust to that, and some more simple means is required for that purpose, as well as for the training of the gun. There is, of course, also a difficulty arising from the captain of the gun being separated from his men; he does not see what is happening below, if

a shot comes in. I utterly deny that in any armour-plated vessels that we have, or that the French have, rolling, as Admiral Paris describes them, six or seven times a minute exposing many feet of undefended bottom, I utterly deny that there is any security whatever against shot. I won't say against all shell, the armour-plates are safe. Mr. Whitworth has demonstrated that they may be pierced; but I attach very little importance to that, because if a spherical steel-shot is capable of breaking any large portion of an armour-plate into fragments, that is quite as formidable as any shell that can be projected through armour-plates. The general praise I, as a naval officer, beg to give to the whole arrangement is, therefore, qualified by very few and unimportant matters; and I am quite sure that I may sit down fully aware that Mr. Cunningham will bring much greater science and skill to the eliminating of those difficulties than I could possibly suggest.

Commander Colomb, R.N.: Is it necessary to keep the drums of the shaft polished on which those ropes are run? Because they are obliged to keep them polished in using them for hauling up timber and matters of that sort; and a very little roughness is sufficient to give friction to hold the rope when not intended.

Mr. Cunningham: No; I should think not.

The Chairman: It is a question of detail, and very simple.

Commander Colomb: With reference to the revolving joint, I do not think we need fear about that, seeing that Penn's oscillating engines do a very great deal of work upon the same principle.

The Chairman: I think the subject before us a very important one. It is quite clear, that with such very heavy guns there will be very great danger where ships roll so fast and so far; and it is desirable to have something more specific and trustworthy than mere manual labour. Of course, difficulties will arise in every mechanical arrangement; but the question to consider is whether the difficulties you have to contend with at present are not greater? It appears they are. I have often found it myself; and we all know very well, from the experience of the experimental squadron, that the men lost entire control over the guns. They turned quite round, upset, and did all sorts of things when the ships were rolling. It was not simply the fault of the carriage itself. Though, with a different description of carriage, the same thing could not precisely occur that occurred in this instance, still the gun would get beyond the entire control of the men. I think that much less difficulty would arise from this plan of Mr. Cunningham's than from those mentioned; but at the same time I am of opinion that this is a question which ought to be considered, whether we are not taking too much for granted in supposing that it is necessary to have such *very large guns.* I am quite sure of this, that it would be much more important if the public mind were set in the direction of making *smaller guns more efficient.* I am quite sure that they will do more than has been done. We see in the case of Mr. Whitworth, with his small calibre, what very great work he does. I believe that the arguments that we have heard here, about the great effectiveness of the large calibre guns is a mistake. I am confining myself simply to the charge as it was illustrated by Sir William Armstrong and Mr. Bashley Britten, the latter of whom was arguing the surperiority of his gun over Sir William Armstrong's, by showing that the calibre was larger; and, therefore, that he got a larger surface for the charge to be acted upon. But if he did get a larger surface, he got a larger charge to destroy his gun. A large portion of the greater effectiveness of Whitworth's gun arises from the fact that he has got a large charge which takes a long time to exert its power, and gets greater effective power without injury to his gun. If that principle were applied to guns of small calibre, it would not be necessary to introduce these very large guns. And the same objection occurs with respect to the very large guns that are to be in the cupola, where, as has been said by Captain Selwyn, "you have all your eggs in one basket." We have seen, in America, the disadvantage of having only one gun in a vessel. When it gets out of order, then the great vessel is entirely disabled. I believe it is much better to have a larger number of chances. The vessels would then be much more effective, and you would get a greater result by a vessel armed with a number of small, but still effective guns, than you would possibly obtain by a few guns of a much larger calibre. Furthermore, it is a very important consideration, that the smaller the gun is, the greater probability

there is of its long life. This is a very essential point. In proportion as you get larger guns you increase your difficulty of endurance. I am sure you will allow me to return your thanks to Mr. Cunningham for his valuable paper. Like all pioneers, his work will expose him to a kind of target practice in the way of cavils, objections, and difficulties that will be raised; but he is entitled to our great praise for having devised the system, and still greater praise that he has matured it so far as he has. In closing, it just occurs to me to ask whether you think the action of the recoil is so sudden that it would not be liable to damage your piston-rod and injure your gear?

Mr. CUNNINGHAM: The guide-bars within which the piston-rod works, are tied down so securely, that the rod could scarcely be injured by the recoil.

Evening Meeting.

Monday, March 29th, 1864.

Colonel P. J. YORKE, F.R.S., in the Chair.

LIST of MEMBERS who joined the Institution between 16th and 29th February.

ANNUAL.

Disney, E. J., Capt. Sussex Rifles
Potts, W. J., Ens. 23rd Mdx. Rifle Vol. 1*l.*
Clay, T. S. Lieut. 103rd Roy. Bom. Fus.
Pickwood, E., Lt.-Col. St. Kits Militia, 1*l.*
Collett, H., Lieut. Bengal Staff Corps, 1*l.*
Bassett, W. W., Capt. 56th Regiment, 1*l.*
Boyle, Alex., Capt. R. N., 1*l.*
Hughes, A. C., Lieut. 2nd Life Gds.
Hore, E. G., Capt. R. N., 1*l.*
Talbot-Harvey, W., Major 1st Middlesex Engineer Volunteers, 1*l.*
Liddell, W. H., Commander R.N., 1*l.*
Perceval, H. L., Lieut. R.N., 1*l.*
Pooley, Hy., Capt. 3rd Ches. Art. Vol., 1*l.*
Farquharson, G. Mc. B., Capt. 20th Rt., 1*l.*
Traill, Wm., Assist.-Surg. 91st Highldrs.
Prendergast, G. A., Capt. 5th Ben. Cav., 1*l.*
Gregson, Jas. D., Ensign 40th Regt., 1*l.*

ON ARMOURED OR IRON-CLAD SHIPS—THEIR ADVANTAGES AND DEFECTS.

By Captain Jasper Selwyn, R.N.

It will be my task to-night to lay before you some remarks on the great change which is now in progress in the nature of those vessels, by means of which naval warfare is carried on—the true walls of Old England, whether built of wood or iron, whether scientifically propelled by steam or driven less certainly by the winds of heaven.

Great errors are, unfortunately, the almost certain concomitants of great and sudden changes of system, but it is the province of science to take early note of such errors, and to prevent, if possible, their recurrence; therefore, I am about to give, so far as I am able, a due weight to the advantages to be derived from armour-plating and other changes, but more especially to note the defects, ascertained or theoretical, which may retard the speedy reconstruction of our navy, or render it unduly expensive.

It is always more pleasant to be able to give praise than to be com-

Names of Vessels	Tons	Horses Power Nom.l	Guns	Plating	Backing	
BELLEROPHON	4246	1000	14	6"	10"	Wholly Plated
WARRIOR BLACK PRINCE	6109	1250	40	4½	18"	Partially Plated
DEFENCE RESISTANCE	3720	600	16	4½	18"	
HECTOR VALIANT	4063	800	32 34	4½	18"	Wholly Plated
ACHILLES	6080	1250	35	4½	18"	Partially Plated
MINOTAUR AGINCOURT NORTHUMBERLAND	6621	1350	50	5½	9"	Wholly Plated
PRINCE CONSORT CALEDONIA OCEAN	4054	1000	35	4½	8"	Partially Plated
PALLAS	2372	600	6	4½	7"	Wholly Plated
ROYAL OAK ROYAL ALFRED	4056	800	35	4½	8"	
ROYAL SOVEREIGN *Turret*	3963	800	5	5½	17"	Wholly Plated
PRINCE ALBERT *Turret*	2529	600	5	4½	18"	
ZEALOUS	3716	800	20	4½	8"	
FAVORITE	2186	400	8	4½	10"	
RESEARCH	1253	200	4	4½	6"	
ENTERPRISE	990	160	4	4½	6"	
LORD WARDEN LORD CLYDE	4067	1000	36	4½	10"	

J.R. Jobbins

pelled to blame, and I shall, therefore, commence by acknowledging the great progress which has been made in the construction of armour-plated vessels since the days of the "Meteor" and "Trusty," and particularly the great improvement in certain qualities, as shown in the "Bellerophon." The "Meteor" and "Trusty" class were little, if at all, less awkward under their load than some of the extraordinary craft with which our transatlantic cousins have astonished and amused all who know what naval structures ought to be. The Americans had, it is true, a peculiar work to do, in their great rivers, and along their shallow-water shores, and we suppose they are satisfied with the very peculiar structures which they built to do it, but we should be sorry to see any imitation of them in England, for whatever else the "Monitors" may answer for, it is certain that they will not do for the ocean.

The advantages which should be obtained from an iron-clad vessel are evidently, if she is worth building at all, an absolute resistance to shell, and considerable resistance to shot. More than this, no vessel is fit for war if, when rolling or heeling over, shot and shell can be sent through her bottom, and so, or by a blow from a ram, she may be immediately sunk.

Unhappily, shot are little less destructive than shell whenever they do pierce iron plates, for the number of pieces into which the interior part of the plate is driven, together with the rivets, nuts, bolts, &c., form a species of langridge, the effect of which is not less to be feared in a crowded deck than that of the most formidable shell.

Now, I believe that no one here will wonder that I should have been puzzled to find out many other advantages than those I have stated as theoretically obtainable from armoured ships. They are certainly not more comfortable to live in, and undoubtedly they cost much more than any previous form of vessel. Where wood backing is used it is doubtful if they are much more exempt from decay, while it is quite established that they are much more "lively," and "liveliness" means disintegration, when it is used to express the rapid motion of a vessel at sea.

And even when wholly constructed of iron, there is, as I shall presently show, an insidious force at work which mocks the puny efforts of man to give the character of real durability to any of his structures. I speak of electricity, whose effects, though they cannot be entirely prevented, may yet, by care and attention, be considerably diminished. As then it appears that the principal, if not the only, advantages of armoured ships are those which I have alluded to, it behoves us to inquire whether we have got the greatest obtainable measure of them for our money. The accompanying Plate VIII shows the size, power, and armament of 25 vessels with the thickness of plating, backing, &c., to each.

First. Do existing armour plates up to 5½ inches give us entire protection against shell? I think it may safely be asserted that they do,—for though Mr. Whitworth has been able to puncture armour with shell, no shell effects followed, for none of the pieces pierced the lining of the vessel.

But there is no doubt whatever that a properly-constructed smooth-bore gun, or a rifled gun capable of firing spherical steel shot, can be made, of no greater calibre than the 8-inch, which will drive its shot through any $5\frac{1}{2}$-inch plate, however backed by wood. It may be said that no effect like this has yet been produced, I answer that a fair inference may be drawn, that if the 110-pounder smooth-bore could do what it did at Portsmouth, with such a charge, then a gun (of steel or alloy), capable, without injury, of firing a full third of the weight of its shot as a powder charge, ought to and probably will do what is here claimed. At any rate an increase of calibre to 9-inch or 10-inch, which is by no means impracticable even for broadside guns, will give us all the power required to penetrate $5\frac{1}{2}$-inch plates. In short, it is almost certain that except, perhaps, the "Bellerophon," no ship now built or building could resist such an attack even from single guns, far less from a broadside concentrated on a single plate; and I do complain, that not only has not proper attention until lately been given to the effects of smooth-bore guns and spherical steel shot, but that no experiment has been yet tried which gives any idea of what would be the effect of a concentrated broadside from a vessel like the "Warrior" on armour-plates. It would, indeed, be lamentable if, after the vessels now under construction have joined those which are afloat, the nation were to be told that they, like their sisters, were "errors or mistakes." I quote from the speech of the chief constructor as published in the *Times* of 27th November last, and so far as protection against shot goes, he is certainly not far wrong. But I cannot believe that he really expects to get anything like high speed, 14 to 16 knots, out of materially shorter vessels with the single screw, all other conditions being equal, while the handiness he seeks, with many other good qualities (speed included), may be given to any ship by the use of twin-screws, as advocated so long and so ably by Commander Symonds.

There are certain desiderata in a man-of-war which almost amount to *sine quâs non.*

The first of these is high and lasting speed united to good manœuvring power, for without these the weakest ship may, in these days of steam propulsion, set the most formidable at defiance. The second is a great degree of unsinkability. The third is comparative safety to life in combat. The fourth is durability.

We will now proceed to consider these seriatim, and, according to their value, pointing out how far they have been secured, and what farther means are available in order to obtain them in the highest possible degree.

High speed can be obtained by two means. Improvement in the form of vessel, or improvement in the motive power. Of these by far the most valuable is the first, for as the resistance increases in some ratio nearly approaching the cubes of the velocity, it follows that to double the speed of any given vessel you must nearly cube the horse-power. Accordingly, as might have been expected, attention has been constantly given to the improvement of the lines of floating structures, and it would seem to be little short of folly to ignore or

deny the value of great length, evidenced as it is by the performance of every modern vessel.

But if we have attained the limit beyond which we cannot go in this direction, without incurring other inconveniences which are too serious, we may at least consider whether, in the case of motive power, we have also arrived at a boundary which it would be unwise to pass. To double the area of the screw by placing two under the counters, or still better in double keels, instead of one in an aperture in the dead wood is not only to give a greater area of push against which the engines may at all times usefully exert their power, but also to place the screws where the water will most freely arrive at and depart from them, and I cannot understand why something more than a launch or a gunboat has not by this time been built by the Government, after having so many opportunities of seeing, in merchant ships, strong confirmations of the value of the principle. I am sure that in the "Enterprise," if she is to be anything but an enterprise of sluggishness, some such trial might usefully have been made, for with a contemplated speed of 9 knots (and it is seldom that the "contemplated" speed is reached in practice), she will be a bore to her friends, and a laughing-stock to her foes. Many an impatient puff of steam and temper will come from the squadron or fleet which has to tone down 12 knots to 9, in order to keep pace with the slowest top of the day.

But speed may be high yet not "lasting," from several causes. First, small fuel-carrying power, here, experiments ought to be in progress to ascertain the best sort of fuel—the best way of carrying and using it Petroleum, as fuel, has received so high an encomium from the American engineers appointed to examine into its use on board steamers, that it ought immediately to be inquired into in this country. Also the best form of boiler, and economy of heat should be always under examination; and when I speak of experiments I do not mean building a 6,000 ton vessel costing half a million, to see whether she will steer like a boat, or trying whether from one particular gun a shot costing £50 can be made to pierce a target costing £5,000, but experiments worthy the name, such as Count Rumford or Colonel Beaufoy, might have superintended with pleasure, and men of science of all future ages might appeal to with confidence. Who can say that this is now the case? Who can read the accounts of, or see the results from the Shoeburyness practice-ground, without feeling that these are attempts to prove foregone conclusions by whatever means,—not step by step, well directed, straightforward searches after truth. Has a single principle been established? Do we know the best relative thicknesses of armour and backing? Do we know anything on the subject as we ought, considering the money and time spent, except that there are certain guns of which we have made a great many that are not safe to use? and a certain thickness of armour which covers John Bull's best ships, which almost any steel shot can pierce.

To return to the subject of speed: besides being short of fuel, there is the fouling of the bottom, which may prevent speed from being asting. The problem of keeping a ship's bottom clean, is one of the

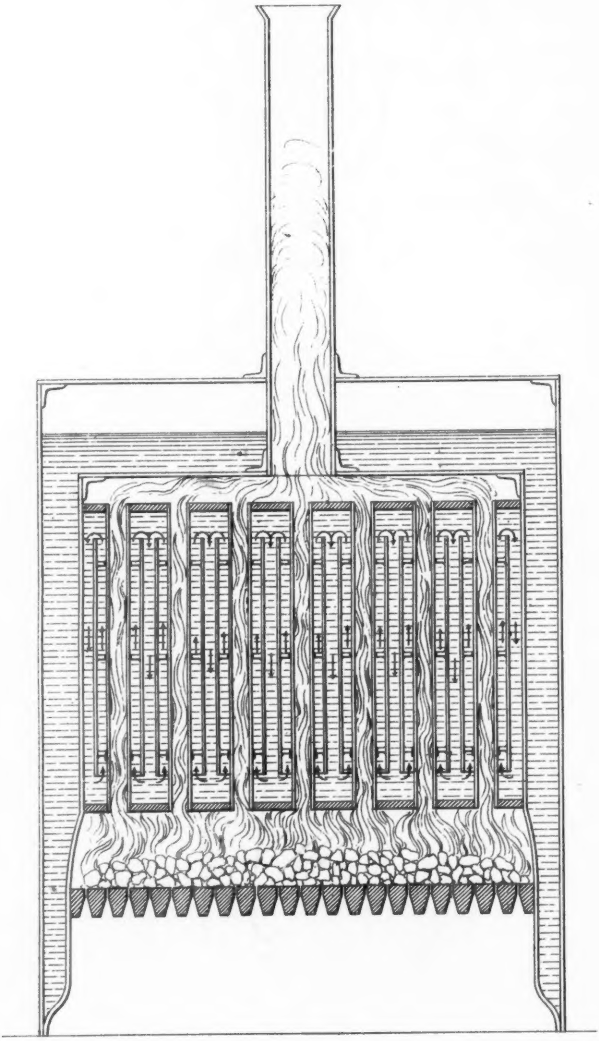
very greatest importance, and I have for a long time been examining what has been or might be done in this direction.

We have first to lay down the principle, that no substance ought to be used such as zinc paint, or other mixture which may exert an injurious galvanic action on the strength of the ship, if built of iron: secondly, that any application to be valuable, must possess one of two qualities; either, like copper, it must renew its surface by slow corrosive action, or like mucus it must be capable of remaining fluid, yet without washing off. If neither of these can be secured, then it must be such a substance, so applied, as that its renewal can take place constantly, or during a sea voyage. Now, with iron ships copper is out of the question; there is no possibility, short of casing the entire ship by the galvano-plastic process, of preventing the excitation of a galvanic current, and the consequent rapid decay of the iron, which is the inferior metal in this galvanic couple. Even if the metals could be separated, the salt water would act as a conductor, and we have to deal here with enormous quantity, though low tension; therefore copper, or any other sheathing which is of metal, or includes metallic compounds, higher or lower in the galvanic scale than iron, is inadmissible. If we were to be contented with any paint of any sort, perhaps ordinary coal-tar would be the best and cheapest.

But let us consider the question of a mucous substance. This is the means which nature adopts to preserve fishes from incrustation; and I have long ago had occasion to observe, that diseased whales and other fish which have lost the power of secreting this, speedily become covered with barnacles and the other shells and weeds which generally attach themselves to a ship's bottom. Is it possible to obtain a substance which shall have, when put on metal immersed in salt water, the characteristic of insolubility, combined with sufficient adhesiveness to remain on, and enough sliminess to prevent the deposition of the young shell-fish, and the germination of fuci, &c. I think it is possible to find such a substance, but if not we might consider that oil and grease do, at their issue from the bilge-pumps and blow-offs, get rubbed against and clean a ship's bottom during their upward passage to the surface of the water, forced as they are against the bottom by the pressure of the column of water which supports the ship. I do not think it difficult to provide for the issue of the oil near the keel, of course under pressure, and so for its general distribution over the bottom of the ship; but supposing a chemical substance approaching to mucus to be obtainable, I should prefer it, as being probably least expensive and more easy of application.

A few words more on the subject of the application of heat. The present tubular boilers are most defective instruments for heating water economically. There is, first, no provision whatever for the necessary interchange of the currents of heated and comparatively cold water. This might be, and I believe in some instances has been, secured by the use of double concentric vertical tubes, which allow the heated water to ascend between them while the cooler descends outside (see Plate IX). Secondly, it is well known that nothing yet invented will entirely prevent the incrustation between horizontal tubes, that is, on the upper and lower sides of each tube, often making a solid

DOUBLE CONCENTRIC VERTICAL TUBED BOILER.



J.R.Jobbins.

mass of non-conducting material between what should be the most valuable part of the heating surface and the water. Some change in this direction is most necessary, and I believe the only obstacle to vertical tubes has been an idea, I think not well founded, that they would necessarily interfere with the low position of the boilers supposed to be desirable in a war ship; but if the ships be really and effectively armour-plated, this ceases to be a matter of the first necessity, even were it proved, as it has not been, that high boilers are inevitable consequences of vertical tubes. There is also the coil system, originally Perkins's, in which water enclosed in a wrought-iron coiled tube is brought to a red heat, and evaporates the water in the boiler. Under a modification of this idea, patented by Mr. A. Longbottom, C.E., I find a report of trial published by the Abbé Moigno in a French magazine (*Les Mondes*), which is edited by him, giving results which amount to 15lbs. of water evaporated by 1lb. of coal, the ordinary duty done in our best boilers being 8 to 10lbs. Even these results are not what might be obtained by a better form of boiler than that employed, for instead of making the shell of the fire-box available as heating surface, there was a brick furnace for heating the coil, and a separate reservoir or boiler in which the heating coil produced its effect. So much upon speed and bottom, as I have in a former lecture called the lasting power.

I have said that good manœuvring power is almost as necessary as speed. I know of no more efficient way of obtaining this in the future than by the use of twin screws, or in existing single screws by the use of Mr. Lumley's highly ingenious and efficient rudder. Fins, bow-rudders and bow-screws are alike defective, for whatever water comes to them none can get away clear from them, and they are serious impediments to the use of the ram. But before we can manœuvre these armoured ships, or at least some forms of them, it is necessary that some new means of seeing without too great exposure be devised, and in aid of this I will beg you to look at a prism rifle-sight (a rectangular prism of glass or other transparent substance) which I invented some years since with the view of preventing the necessity which now exists at long ranges in rifle-shooting of raising the cheek from the butt, and otherwise losing steadiness of position in order to fire at long ranges. The result of its use on the top of a cupola or elsewhere is, that it enables your eye, like the Irishman's gun, which shot round corners, to see without being seen.

Let us now turn to the next desideratum in armoured men-of-war, a great degree of unsinkability. It has been improperly assumed that wooden-bottomed ships are more unsinkable than iron, however, constructed. The reverse of this may be shown to be the case. If we take an iron or steel ship and put her upon a rock with the ordinary wave motion in such situations, the iron or steel bottom will be driven in where the rock touches it, but the force applied will very slowly deduct from the general strength of the structure. A hole may be made through an iron ship's bottom, she may have, as in the case of the "Great Eastern," 40 feet in length stripped out of her bottom, and yet little will be taken from her strength. Now I am not going to say

that this point of unsinkability has been left entirely unconsidered, but only that it has not been sufficiently considered in our modern iron-clads. In the "Minotaur," for instance, the bottom is double, like the "Great Eastern," *i.e.*, there are two skins, 2 feet or so apart, and which are divided into cells, and there are longitudinal box girders, which divide the whole length of the ship, together with, I think, 6 transverse bulkheads. But even this, great as the advance undoubtedly is, is far short of what might be done were the material adopted steel plates, and the system one of a congeries of cells, in shape imitating the honeycomb. In every part of the ship up to a line representing the planes of her ordinary inclination or heel, with perhaps the sole exception of engine and boiler space, this system should be carried as far as possible, and then for the first time we should possess a vessel unsinkable by anything but very prolonged violence. I am quite sure that rams will have fearful effects whenever twin screws are used, as I hope they will soon be throughout our navy. No objections can be valid which depend for their sole force on the fact of certain stowage being necessary for certain purposes, and that it has hitherto been obtained in particular ways. Water may be carried as well in fixed cells as in moveable tanks. Provisions and stores must be stowed in subordination to the first necessity, which is that they should not all go together to the bottom, when a big shot catches a rolling ship, or a ram unhandsomely tickles her ribs. We now come to the third advantage specially to be sought in iron-clad ships, comparative safety to life in combat. Without this be largely obtainable, we may as well give up armour plating altogether, therefore we will inquire, What armour do we carry? What armour ought we to carry? What armour can we carry? In answer to the first question, if we except the "Bellerophon," which is no doubt a step in the right direction, no other vessel carries more than $5\frac{1}{2}$ inches of iron over any large portion of her surface, while the "Warrior" and her class carry $4\frac{1}{2}$ only. But the difference between them of 1 inch of iron is more than made up, in fact is believed to be turned in favour of the $4\frac{1}{2}$-inch plates, by the circumstance that instead of the 18-inch wood backing of the "Warrior," the vessels which carry $5\frac{1}{2}$-inch armour have only 9 inches of teak behind their armour. Now the specific gravities of teak and iron are respectively ·750 and 7,264 water, being 1,000, or to put it in other language wrought iron is 7 times heavier than water, and teak is less heavy by $\frac{250}{1000}$, about $\frac{1}{4}$. Therefore leaving bulk out of the question, and the mode of construction in wood, we can roughly say that we can afford to carry about 7 times as much wood as iron. But it is doubtful whether this is not working in the wrong direction if we consider that the crushing force which good wrought iron will sustain is to that of teak as 25 tons to 6 tons nearly, these being about the respective moduli of elasticity to which the force to resist crushing always bears a just proportion. But with impact to deal with, we have a new element in the calculation. Among the experiments of which I before spoke, most valuable would be a series which should give us accurate measures of the force exerted, say by a steam hammer and punching-machine, in crushing or piercing iron, steel, wood, &c., of

varying thickness, backed by various materials. These would not be expensive, and could not fail to yield most useful information. However, as in the case of metal for guns, we shall be most unwise if we do not try to understand and make use of the metal which *ab initio* promises the best results. Need I say that I point to steel, which may be made at little, if any, more expense than iron by Mr. Bessemer's process, and if used for the hull alone will, he promises us, enable our iron-clads to carry 9 inches of iron, instead of 5½. Now this would be an advance indeed, and surely it is little use proceeding with any more ships, until the value of this assertion be tested. We do carry then from four and a half to six inches of iron armour. We probably can carry nine. Therefore, we ought to carry that, or more, if practicable. I should think that guns have furnished enough specimens of how not to do it without adding ships to the list. Depend upon it that if we do not test these things at home, there are others abroad who will, and it will be too shameful if, after having sent an officer to see guns in America, the best of which were devised if not made in England, we next sent a shipbuilder to France or Russia, to see the application of English steel to foreign ships, or worse still if, from the extent of the damage we receive in war from foes, we first learn the value of the safety offered us during peace by friends. I am perfectly aware of the great difficulty, not to say impossibility, of official examination of all these inventions. Not only do officials often feel for want of time utterly unable to attend to them, but often if the time were given, the subject is one which, being purely technical, they would wisely decline to decide on. If not to scientific institutions supported by Government, there is no other reference possible, and I believe that some day reference will be made as a matter of business to the scientific bodies on all inventions and proposals which seem to promise well—in each case to that body whose special knowledge entitles them to pronounce *ex cathedrâ* on that particular scheme. A favourable report from men above suspicion would entitle the inventor to further trial, and would be the best guarantee for Government against that Parliamentary scarifying which all parties are so anxious to avoid, and if the report were against the inventor, would justify the neglect of the invention so far as Government were concerned. Men will say that this is already done in a different way by the appointment of Select Committees, Royal Commissions, &c., &c. True, if politics had not sometimes more to do with such appointments than science. True, if the jury were always devoid of personal interest in the question. Be this as it may, in some way or other all that is good, as well as new, should be encouraged, not repressed; protected, not robbed.

I should be doing an injustice to a friend and brother officer who has striven, I hope successfully, I am sure most ably, to conquer a lasting reputation on the question of armour and the protection it should offer to life in combat, did I omit to speak of Captain Coles' cupola-ships in my paper? He has been good enough lately to forward me a pamphlet, in which he conclusively shows that many of the objections which apply to the American form of turret do not attach

to his cupolas, and I have no doubt that where the twin-screws are not used, or cannot be used, as the means of turning, his cupolas offer great facilities for the mounting and management of very heavy guns; and while on this subject I will try to overturn a nonsensical, though popular idea, that there ever has been, or will be, a gun made which cannot be carried in a gunboat with the greatest facility as a pivot-gun. The proportionate weight is nothing, witness the long 32 in a Swedish row-boat, particularly if hydraulic or other power be applied to raise it from the hold, when loaded, and about to be fired, which may easily be done, and to a plan for doing which I hear that another naval officer is turning his attention at Liverpool. If this be accomplished, an armoured "close quarters," as our ancestors named them, may be constructed round the gun below, in which in action the crew may be assembled, and whence the gun may be raised, pointed, and fired without the exposure of a single man. Here no armour casing outside the whole ship would be needed, a weak point with the present cupola system, provided the vessel be rendered unsinkable by the means I have pointed out, nor will any damage to the walls of the close quarters, which may possibly occur, be visible to the attacking vessel, so as to enable her to repeat the dose on that particular spot. I think that if the crew at their guns, the vital parts, engines, &c., be protected, very little is needed for the rest of the hull above water, and it is on this principle alone that armoured ships of moderate size can be constructed to fulfil the desideratum of great speed, which is, as I have previously said, of the first necessity; but as I doubt the truth of the conclusions which have been drawn that there will be no more yard-arm fighting or boarding, it will not do, I think, to confine the crew to a box, out of which there is only one upward issue, except through the ports, as is the case in the "Enterprise," and in which, if she is ever boarded, the crew may be stifled or otherwise destroyed, like rats in a hole, before they can get out. So much has already been said against the policy of having very large ships to carry very few guns that I need not here repeat those objections, but I should like to hear how a very serious difficulty is to be overcome when we have such guns in such ships, and which arises from the fact that when heeling or rolling the real gunwale of the ship is interposed between the gun and its object. As all naval officers are aware, though perhaps not all naval constructors or artillerists remember, if your ship heels 6°, and the object is at point-blank distance, the weather guns must be depressed 6°, and the lee guns elevated 6° before they can be laid horizontal, and whatever further elevation is due to a greater distance of target is taken from the weather depression or added to the lee elevation. Now, in such a case I do not see how the weather guns of a cupola ship can be fired at all without shooting away the side of their own ship, or else having an undue elevation and so going over the object. Again, take the case of rolling motion. At the top of the inclination to port the starboard guns have lost sight of the horizon by the interposition of the gunwale; the contrary occurs with the roll or inclination to starboard. This is very unfavourable to accurate aim,

and I am afraid it would be undesirable to raise the weight of the cupola so high as not to produce these effects.

But if we have succeeded in building a man-of-war at last, which has high and lasting speed, with great manœuvring power, which is in a considerable degree unsinkable, and which offers the greatest attainable safety to life in combat, there is only the more reason why we should take every possible means to make so perfect a structure as durable, as science, skill, and attention, can make anything put together by man. Therefore, we will proceed to consider the causes of decay and disintegration, the causes which lessen durability; among these, electricity, which in some measure accompanies or causes almost every change which is undergone by bodies, either organic or inorganic, comes first, and is of the highest importance; I have very little doubt that the hole in the "Harbinger's" pump-well, which the jury in that trial were so anxious should be accounted for, was caused by an electric current, added to, and perhaps in some measure caused by, the vibratory movement of the sounding-rod. That vibratory movement under certain circumstances of inclination in the magnetic meridian of the sounding-rod would be sufficient to make a magnet of it—an electric current caused by the bilge-water—the plate and the iron rod would be set up, and as fast as oxide was formed at the point of contact of the metals, it would be broken away by the tapping, and a hole would soon be formed. Some here may doubt how far a current of electricity can be formed between two pieces of apparently similar metal, but it is now well known, not only that the same rod or wire, heated at one end and cooled at the other, will generate an electric current; but that, commercially speaking, no metal is ever made so perfectly homogeneous, as not to afford such currents, by immersions of separate portions of it in weak acids and water. Here is a battery cell, in which the copper and zinc of the ordinary galvanic arrangement, is replaced by two pieces of iron, cut from the same bar: you will see that the needle of the galvanometer, a delicate suspension one by Messrs. Elliott, is moved at the instant of making contact, and though I cannot here show you the enormous quantity battery which would be afforded by the large surface of a ship's bottom, and have, therefore, been obliged to use acidulated water, instead of bilge or salt water, yet the lesson conveyed remains the same. The bilge-water, there is no doubt, contains several acids, principally of course muriatic and sulphuric, this latter gives evidence of its presence by the evolution of the disagreeably smelling sulphuretted hydrogen gas, and under these circumstances, a galvanic current, of great quantity but low tension is constantly going on. A very common instance of the decay of iron from galvanic action is to be found in iron railings by the water side which have been let into the stone pavement, and secured there by lead cast into the socket. You will find that it does not take many years to eat through a cubic inch of the iron under these circumstances, and I attribute the dropping out of iron rivets in ship's bottoms almost entirely to galvanic action, not to any attrition, which would act as much on the surface of the plates did it exist, and would be shown at the sides of the rivet-

heads, not by general decay of the whole head. The injurious galvanic action might be entirely prevented by coating the bottom inside with a common insulator, such as pitch or asphalte, and if done this would probably add many years to the duration of all iron ships. If steel be eventually used, this precaution becomes still more necessary, for the metal will be originally thinner, and can the less afford any such decay. I think we may safely say that if the galvanic action be impeded or stopped, if that were possible, there is no other cause of decay properly so called, and there remains disintegration, which is now likely rapidly to take place, from the vibration set up in our modern ships by enormous screws, improperly located. Here again the double screw offers advantages by no means to be neglected. The weights are diminished, the vibration is materially lessened, and one screw and engine will often do the duty required, while the other and its boiler is undergoing the cleaning, without constant attention to which there is great loss of power. Besides one screw and engine of 100 horse-power will often give a better effect than the half-power of a single screw with a 200-horse power engine, particularly in aiding the sails as an auxiliary. Thus then there is a cause of disintegration and loss, eliminated by the same means which accomplishes other important results in manœuvring and speed. I will now close my paper by thanking you for the patient hearing you have given me, and trust that discussion on the points I have raised will make the little which I have been able to say upon them more valuable than it could otherwise have been to the members of this Institution, and the rest of the public who take an interest in this important question.

Before sitting down I should like to make a few further remarks on some of the subjects shortly brought before you in my paper. In the diagram (Plate VIII) you will see that the ships building or to be built vary in every possible way; that some vessels carry 18 inches of wood, and some 9 inches; that we do not appear to know what relative proportion of strength is given by the wood and the armour plating,—how many inches, that is, of wood, represent how many inches of iron.

You have here what they all carry. Here is the "Bellerophon," with 6 inches of armour, but unfortunately there is in her much less wood backing than in many others, and we have learned that there is a certain value to be attached to thickness of wood, greater than that which was supposed when they were constructed; but it is a very lamentable thing that there does not seem to be any effort making to stop the construction of that which we all acknowledge to be an error. I know that several of these are still on the stocks, and probably a little pressure brought to bear in the right direction might give us something in the shape of a ship's side which we could rely upon, instead of putting these in the water as they are, and then calling them errors and mistakes.

In explanation of what I have said as to guns placed in cupolas, you have here the model of Captain Coles' cupolas, and the way in which they are placed. You see at once, so long as the vessel is on an even keel, it is perfectly true that you may fire your gun with five or six degrees' depression. So long as the ship is upright, the gun will

depress, say six degrees, and it will strike the water, Captain Coles claims, and I believe quite correctly, as near as could be done with guns on the broadside, if the ports remain as at present. But there is this remarkable difference, that directly that level alters, and the heel becomes greater than six degrees, then, in the cupola ship, you have the ship's side interposed between the gunner and the horizon, and there is no possibility of firing at all. That occurs whenever the ship rolls; it occurs also when she heels over, and your weather guns, if you are attacked on the windward side, are subject to an incapacity of firing when the ship heels more than six degrees, and to a great difficulty in firing when she rolls, for I need not tell any artillerist that at the top of the rolling motion, which is the time chosen generally to fire, the line of sight is here totally impeded. Still more does this apply if we consider the cupola guns as firing with the ship pitching; for then you have got your ship possibly pitching, as I have often seen them at sea, with fifty feet of their bow out of water. Now, how are you to fire your gun? You must wait till you can catch her just half-way between the downward pitch and the upward one; and it would be, in fact, very like putting men at a loop-hole to shoot partridges going past in full flight.

Referring to the diagram of the boiler, you will see that there are concentric vertical tubes placed about the other vertical tubes coming from the fire, which communicate with the outer air by the chimney. Between these tubes there are studs which support the outer ones. I am not aware by whom this has been proposed, but I believe it is now used in Shand and Mason's fire-engines. Under these circumstances, the heated water being confined close to the tube through which the fire passes, it ascends and is constantly replaced by the cooler water descending from above, and passing in at the bottom, thus causing a thorough interchange of the water in the boiler, and probably preventing, in great measure, any tendency to prime.

In the tubes as they exist in one of the ordinary tubular boilers, although it is possible to force a chisel down between them vertically, and thereby to remove incrustation, it is utterly impossible to get a chisel between them horizontally. It has repeatedly come under my observation that those surfaces become connected by a solid wall of lime incrustation, carbonate of lime. The result is that these upper sides of the tubes which ought to be the most valuable part of the heating surface are rendered entirely nugatory.

Referring to the prism, on which I touched in the course of my lecture, you will see at once by sliding it on to the back sight of the rifle, you get the ray of light coming from the object deflected to the eye, without the necessity of raising the cheek from the butt, or lowering the butt under the arm. It is evident that precisely the same means may be used to give a power of seeing without being seen from the interior of the turret ships or cupola vessels, such as we have not yet acquired, and the absence of which is very much lamented by the American officers in their late reports on the subject.

Again, to revert to the main portion of my paper, it is utterly insufficient to armour plate, as if vessels were going to remain constantly on an

even keel. That is a mistake which unfortunately has been made to a very great extent, and which makes every seaman say, the instant those vessels get to sea, they have a weak part like the alligator, which you may attack, and without wasting shot on a defended part. It is not sufficient to put a skin inside, divided into cells, or to have a few great divisions in the bottom. We must modify our whole structure, and make as much of it as possible—a congeries of cells, into any one of which not more than 20 tons of water can enter, and these must be highest towards the side, or "in the wings," that is to say, they must come into the planes of inclination.

I will now ask you to allow me to show you an experiment, which conclusively establishes the fact of the galvanic current existing. I have here two pieces of iron cut from the same bar. Some people will say, "Oh, the ship's bottom is entirely of iron, we do not propose to use copper, and the quantity of brass and copper which is inside is not absolutely connected with the ship's bottom, therefore we shall have no galvanic action." I have watched with great attention sundry processes which have proved to me that there is galvanic action, and having been forced to study electricity from another pursuit of mine in the telegraphic world, I have striven to apply the knowledge so acquired to the solution of questions which have occurred to me in my profession as a seaman. I have got here, I must tell you, sulphuric acid and water, because, as it is utterly impossible for me to give you the extended bottom surface of a ship, I cannot show you in any other way the quantity of the current which would be obtainable from a ship's bottom, and which exerts a most important influence. If you look at that needle in the delicate galvanometer before you, you will see the instant I make contact, it is deflected. That shows a current passing. It is one of those delicate galvanometers constructed by Mr. Becker, of the firm of Elliott Brothers, which are so beautiful in their results; and this, I will tell you, is so delicate that the mere contact of two pieces of copper out of the same wire would produce an effect, there being no one metal so thoroughly homogeneous, no two metals so thoroughly similar, that a galvanic current does not pass between them. More than that, I may say, no two woods exist, which, subject to certain conditions, do not give you a galvanic current between them. We have got the evidence before us, without going into the question of how far rivets differ from iron plates, and they do materially differ, that there is a galvanic current constantly going on between them; and the rivets do drop out, not because of the attrition of the coal-dust, but because the coal-dust liberates sulphuric acid, or the wood employed as backing liberates other acids, which, mixed with the bilge-water, evidence their presence by the evolution of sulphuretted hydrogen, a gas which mainly contributes to give the peculiarly disagreeable smell to bilge-water; and that bilge-water is capable of setting up a current, whose effects are sometimes evinced in iron ships, by the dropping out of the rivets at the bottom. Lloyd's surveyor mentions one case in which over 1,000 rivets thus dropped out, and another in which half the plates were decayed in the bottom.

I intended to have prepared wrought-iron, cast-iron, steel, rivets, and so forth; but I have shown you, and there can be no more conclusive experiment than this, two pieces cut from the same bar; therefore, I have not thought it necessary to go into the other experiments. I think you will acknowledge, the lesson conveyed remains the same, although I cannot here show you the enormous quantity due to electric action on the whole of the ship's bottom.

The rivets run in lines, mostly in vertical lines up the inside of the ship, and parallel to each other; of course there are the butts which join across, but you have a number of parallel lines; now, you do not find, as would be the case were it due to attrition, that the sides of the rivet-heads are eaten away, and the other parts left protected, as they would be against the attrition by the next rivet to them; but you do find that the whole rivet-head goes, and the rivet drops out.

The CHAIRMAN said, they would agree with him in returning thanks to Captain Selwyn for the very interesting paper he had read, and for the several very ingenious considerations which he had brought forward, he believed for the first time. He should be happy to hear any gentleman who wished to make any observations on the paper.

Rear-Admiral HALSTED: I may be permitted to make one remark upon Captain Selwyn's proposition, which, if I have understood it right, may go forward, if unexplained, I won't say uncontradicted, and create a great deal of misapprehension in the service upon a point which is very important. I mean where he refers so confidently to the experiments now being made, and lately made at Portsmouth, with spherical steel shot out of the new smooth-bore gun proposed by somebody or other; but it appears that the paternity of it has been adopted by the Admiralty, and has been so referred to by Lord Clarence Paget, Secretary to the Admiralty. One cannot help remarking on that importance which is placed upon these experiments at Portsmouth, not only by the Secretary to the Admiralty on bringing forward, the other day, his navy estimates, but also previously, upon the 9th of this month by the First Lord of the Admiralty, his Grace the Duke of Somerset. They both point out the great value of the supposed invention, and of the increased power of firing the steel round shot out of a smooth-bore gun directed at certain target-ships at Portsmouth. The target-ships selected for these experiments have, unfortunately, been such that it is not possible that any serious consideration can be given to them. Everybody is disposed to give all due credit to an old servant, but that old servant by no means represents the resistance which would be found in absolutely new constructions built for the express purpose of resisting the guns, intended to penetrate the armour-plates now being employed in every navy. I do not think we shall find a single ironclad afloat and built, furnished with her equipment of armour for a longer period than six years. Yet what are the ships which are being selected, and which have been selected for many of these experiments, and for exhibiting that resistance which we shall have to meet in the case of newly constructed ships? I take, in the first instance, that of the "Monarch," built in 1832, and which, therefore, is now 32 years old. I take for the second case—the "America." By good luck she exists nowhere, because she was sunk the other day at the last experiment; but she was built in 1810, and is, therefore, 54 years old. Now, the steel shot for the first time have been sent down to Portsmouth to be fired out of this new smooth-bore 100-pounder gun, whereof so much has been said, and to which so much reference has been made by Captain Selwyn.

Captain SELWYN: I referred also to the old 68-pounder fired in conjunction with it.

Admiral HALSTED: Never until the other day; for the first time on Thursday.

Captain SELWYN: On Wednesday and Thursday last.

Admiral HALSTED: Not upon Wednesday, but upon Thursday only; the first time

it has been done with the 68-pounder. In regard to firing upon the "Monarch," the facts of importance are simply these: The "Monarch," with a 5½-inch plate upon her side, represents an absolute substance at the lower port sill, which is taken as the standard, of 32 inches in thickness, divided between 5½ inches of plate and 26½ inches of the scantling of the ship. Certain steel shot were fired at her upon the 14th of January. When I say the 14th of January, I take my statement from the account which appeared in the *Times* on that day; and of the four steel shot which were then fired, the two first Nos. 1 and 2, struck the edge of the plate, as it is described, and both of them went right through the whole 32 inches, including the 5½ inches armour plating. The third shot stuck with its outer surface two inches only below the outer surface of the armour-plate, and the fourth shot also stuck, whether deeper in, or less deep in, is not stated in the account from which I quote. But nothing can well be more contradictory, or self-contradictory as it were, than the circumstances which I have now adduced, wherein out of four shots fired from the same gun, at the same time, with the same charge of powder, and the same weight and nature of shot, and at the same place, one consecutively after the other, two of them go right through everything, passing the 32 inches of resistance, while the next two of which, of the first only the measure is given to us, enters only 11½ inches altogether, that is to say, about 2½ inches below or within the armour itself, and the 9-inch diameter of shot together; therefore, there was, in that case, 20 inches of penetration yet to be made, or nearly double that which had been made. I have said that no measurement has been given us of the fourth shot, but the description given is similar to that of the third. Now, when we come to the older ship (the "America") we find very nearly the same thing. We find, first of all, a shot which goes through everything—I may correct myself—it goes through everything except 2½ inches. In the case of the "America," I should state, the whole combined construction presented a resistance of 29 inches, three inches less than that of the "Monarch." Then, as I have said, the first goes through 26½ inches only out of these 29 inches, the next goes through 12 inches altogether, that is to say, it stops and is stuck, as the expression is, after it has penetrated but 3 inches below the outer surface of the plate; therefore, before that second shot there is 17 inches yet to be penetrated. The third gun goes through everything again. Now, I ask which of these penetrations is to be considered as the true measure of resistance of the "Monarch" and of the "America?" In order not to be too long, I will take the "America," the last ship fired at. Is it to be the 11 inches or the 12 inches, which left 17 inches or 18 inches still for penetration, or is it the shot that goes through and through all? As I have said before, it being in each case the same gun, with the same charge, the same steel shot, from the same distance, and at the same plate.

Admiral Sir George Sartorious: It has got an additional knee or something of that sort.

Admiral Halsted: All ships have knees of some sort or another that I have ever sailed in; and I am afraid when shot come in they will have to meet with knees occasionally. But here are circumstances of such absolute self-contradiction, it being in all cases perfectly sure that the gun presents no variations; but I do not think it is possible for any person to see how the variations can be attributed to any other cause or reason than that of the variable circumstances of a sound part or of an unsound part, whether in the plates, whether in the ship, or whether in both. I have now spoken of the experiments which occurred on the 4th and 24th of January. Last Thursday there were similar experiments, and what did they prove again? They were both tried on the "America." I will only take two instances, the two particular steel shot which were fired again out of the 100-pounder smooth-bore gun, and also at the same distance, with the same charge, and at the same plate. I will take the case of the 5½-inch plate then fired at, because 5½-inch plates were fired at also before in the "Monarch," and on the previous occasion on the "America." Now, those shots did not even penetrate the plate; they did not lodge, or if they lodged, they lodged only sufficiently that when the second shot struck it knocked out the first. Upon both those occasions there was a projection—I won't tax my memory to the fractional part of an inch, but the shot absolutely projected in both cases beyond the outside, or outer surface of the plate, to the extent, I believe, of more than two

inches; but it is merely a question of memory, which may be incorrect. Now, this is the case again with the "America," the same ship. What I ask is this: the "America" is 50 years old we will say; will any gentleman suppose that that ship has increased her strength since she was built, or we will say from the time she was six years old until the present day? Am I wrong in concluding and asserting that necessarily that ship is weaker now than she was on the first day she was built, or the first six years that she was built? and that her resistance is now absolutely less than it could possibly have been when she was a new ship? When we take this measurement, and when we look to any of these variations in the experiments—in one case the shot going right through and through, and in the other experiment of the shot sticking; it had not even buried itself, and was two inches outside. Which of these two circumstances represent the true resistance of the "America?" Undoubtedly reason tells us that the true resistance of the ship is represented by the shot which penetrated least; and even with that amount of concession, is that the amount of resistance that that ship would have presented at sea as a new ship, or as one merely six years old? Is that a resistance at all to be compared with that which British guns will have to meet when they come to fire against and to contend with armour ships, not one of which, instead of being 50 years old, will be much more than five? Now, the thing I protest against in these experiments more than another is that performances made by any gun, I do not care what the gun is, under circumstances where it is not possible for the resistance to be represented with any truth whatever, compared with the resistance which those guns will eventually have to fight against as when brought against true armour-ships; that that should be put forth to the public as the power of these guns, and that those guns should be pressed upon the navy as enabling us to fire through and through a French armour-ship, for instance, as they have fired through and through the old "America." I think it is necessary to make such a protest against the position of my friend, which will go forth to our Service that such and such is to be the measure—that the measure of the penetration through and through the "America," is to be the measure of the power of the gun which he proposes we should all have to fight an armour ship with.

Captain SELWYN: Pardon me, I particularly stated that it was to be taken as only a comparative experiment.

The CHAIRMAN: I would suggest that it would be better for you to reserve your reply to the last, except it should be a particularly short explanation which you might wish to give of some mistake that may have been made.

Captain SELWYN: Admiral Halsted is arguing against what I did not state. I only wish to say that I particularly guarded myself against saying, or being supposed to say, that these were anything but comparative results.

Mr. VICKERS: I fear that I have no very important information to give. I have a feeling that cast steel will not do for armour plates as they are at present used. The reason for my opinion is that I have made experiments very much of the character that Captain Selwyn says ought to have been made; but instead of using a steam hammer, I have used a more easily measurable test, viz., a ram of 14 cwt., dropping it upon bars of steel placed upon bearings 3 ft. apart, from heights of from 1 ft. to 40 ft., which, of course, give considerable velocity to the blow. Under this test I found that soft steel would resist far more concussion than any wrought iron, and from that I was led to the conclusion that steel was the best material for armour plates, until the trial at Antwerp of cast steel armour plates of Mr. Krupp's manufacture. I dare say many here will know the results better than I do. I simply know that the plates cracked. It at once struck me that his plates were made too hard and brittle, containing too much carbon; but I succeeded in obtaining a small piece of the material, and from a very accurate test I made of its hardness, I found that it was very soft, and that judging by my trials, it ought to have stood the test if steel would do. Any increased softness would not have given additional toughness, and from Mr. Krupp's great experience as a steel manufacturer, I have no doubt that the plates were of as good steel as they could possibly be made. I have come to the conclusion that steel will not do on account of its great elasticity, the blow, when given with such great velocity as that of a cannon ball, being communicated too quickly through the mass, and causing a fracture, while softer material yields at once at the point struck, and

the injury is local. If something could be put in front of the steel so as gradually to take up the blow, that I should say would be the best mode of enabling a plate to resist the shot. Whether such a thing is practicable or not I am not prepared to say. If any other questions should be asked on the subject, I shall be very glad to give an answer.

Sir GEORGE SARTORIOUS: Would a plate of wrought iron outside the steel produce that effect?

Mr. VICKERS: I should think wrought iron outside would hardly be soft enough. It must be something softer than wrought iron. I am not prepared to say exactly what.

Captain HARRISON, R.A., Secretary Iron Plate Committee: There are one or two remarks I should like to make, first with regard to what Mr. Vickers has just stated. Captain Selwyn alluded in the paper which he has read this evening, to the steel not having been used more in ships. I think that what Mr. Vickers has said upon the subject is a very ample answer to that question, viz., the uncertainty of Bessemer's metal. Although it is extremely valuable, yet there is such uncertainty in it that it is not safe to rely upon it altogether for ship-building. Hitherto, although I have no doubt the difficulty will be, and is being, rapidly overcome, I think the reason I have given is a fair one for not using Bessemer's metal for building ships. I am referring to that letter of Mr. Bessemer's which I have no doubt you have all read in the "Times;" and exactly the same thing holds good with respect to what Mr. Vickers has said about steel for armour plates, viz., that it is not reliable, and you cannot use it for armour-plating. In the very earliest experiments made by the Iron Plate Committee to test steel and wrought iron, it was found, that the steel armour-plates sent to them to be tested, up to three-quarters of an inch were far superior to the wrought-iron plates; but the very moment you got beyond three-quarters up to an inch, the plate cracked at the very first shot, and was useless. The gentlemen who supplied those plates to us from Sheffield, eventually gave up sending them. They said they were perfectly satisfied that they could not be used. In all the experiments which have been made from that time up to this, with steel plates sent of various thicknesses, whether to Portsmouth or Shoeburyness, there has always been the same result. We have had steel plates from Sweden sent with very great confidence on the part of the gentlemen who supplied them. They have been tried at Shoeburyness, and at the very first shot away they went, cracking like a pane of glass. Certainly, at the present day there is no doubt that steel will not do for armour-plating. The suggestions that Mr. Vickers made about placing something in front of the armour-plate, would be very good probably, if it was not for that very awkward customer, the shell. But the effect of it is, as we have tried at Shoeburyness, when you face your armour-plates, as has been proposed repeatedly, and is proposed now, by putting projecting substances in front of them, such as layers of wood, alternate plates, and so on, so as to reduce the shock on the armour-plate, the very moment the facing is penetrated with the shell, the shell explodes and blows it away, and your armour-plate at once becomes exposed. Therefore, although it might for a round or two save your plate, it would be but a temporary good. Admiral Halsted made a rather severe attack upon certain experiments that we have read of in the papers, but I think he misconceives the object of those experiments.

Admiral HALSTED: The fact or the object?

Captain HARRISON: The intention of those experiments.

Admiral HALSTED: I thought you said I made a mistake in the fact.

Captain HARRISON: No; not the fact. The experiments, so far as I understand them, and I have seen a good many of them at Portsmouth, are not to test the resistance either of the "America" or "Monarch," as to their power of resistance, in the same way that the "Warrior" target is put up and tested at Shoeburyness, or the "Bellerophon," or any other target. It is not to test the resistance of these ships; it is to test the quality of the armour-plates which are supplied, and also the quality of the steel shot. Admiral Halsted asked how it was that certain steel shot went through 5½-inch plate, penetrated the ship's side, and went out at the other side, whilst another shot fired from the same gun with the same charge of powder, simply stuck in the plate, and projected 2 inches. The simple answer to that is this,

that one shot fired from that gun was a shot probably made of Firth's steel, an extremely expensive shot, or was made by the Elswick Ordnance Company, or at some other place, of extremely expensive steel, whereas the shot which squeezed up and stuck in the plate was a shot made perhaps of Bessemers' metal, costing instead, of £50 or £60 a ton, only £18 or £20 a ton; therefore, it does not do as much work as the very much more expensive tooled steel shot. The object of those experiments, as I said before, was not to see what the "America" ship would keep out, but to obtain as soon as possible steel shot of a servicable quality, and at a cheap rate. We all know that there have been ample experiments made which prove, that if you choose to pay money enough, you can penetrate the "Warrior," or any of those other ships. But the object is now with the experiments that are being carried on to endeavour to get a cheaper steel to do as much work as we can. I may state what result has been obtained at Portsmouth from giving a little attention to the improvement of cast iron. Whereas with the ordinary service cast-iron shot which was fired at a plate, an indentation was merely got of a little over 2 inches, by using cast-iron of the manufacture made in the laboratory, an indentation was got of over 7 inches. I, therefore, think that the experiments which have been carried on, although they may not enable us to see what you gain in resistance as regards the ship, they do give very valuable information respecting the improvement of our projectiles. There is only one more point upon which I should like to make a remark. Captain Selwyn remarked upon the great desirability, whatever else we did, of keeping out shell. We all know the old exclamation which has been heard over and over again, "For God's sake keep out the shell." Certainly in the present day that becomes almost a work of supererogation. I dare say most gentlemen have seen a picture in the "Illustrated News" of an experiment with the 600-pounder which I was fortunate to see myself at Shoeburyness. I certainly think when we get a 600-pounder which can be fired accurately, and penetrate a "Warrior" target, as it did down there at 970 yards' range, the bursting charge of the shell being 29 lbs., I do think it becomes very hard work to keep out a shell of that power, more particularly when this shell is of steel. I may say at the same time that the accuracy of that gun was most remarkable, for at 1,000 yards' range, a wooden target was put just beyond the "Warrior" target, a little to the right of it, in order to get the range and save the steel shell. The first cast-iron shot that was fired to get the range, knocked over the wooden target which was at 1,000 yards distance, and the third shell fired from the "Warrior" target at 970 yards' range, struck the target, and, I may say, absolutely demolished it, because it had been intended to have the target removed to 2,000 yards to try the gun at it, but the target was so completely demolished that it was not worth removing; therefore the experiment could not be tried.

Admiral Halsted: I do not know whether I am entitled to a word as to what has been said.

The Chairman: Merely to explain anything.

Admiral Halsted: It is merely as an explanation. I will only say, I have noticed the experiments made at Portsmouth very carefully, and I would remind my friend Captain Harrison, that the actual proving of the plates has in each case, as stated in the account, preceded the experimental trial, subsequently made with the steel shot, and it will be seen, in proof of that, that in every case the steel spherical shot have been fired upon previously undamaged parts of the plate; so that it is not for the proving of the plates.

Captain Harrison: I said the proof of the shot; the proof of the plates takes place, in the first instance, and the proof of the shot, which takes place in the second, is to test the quality of the shot, and not the resistance of the ship.

Admiral Halsted: Very good. Then there are terrible differences, irreconcilable differences, in steel shot.

Sir George Sartorious: My opinion for some time past has been, that in the contest between the gun and the plate, the gun will have the advantage. What I have just heard from Captain Harrison, I think, is quite conclusive. Of course, every sailor knows that a ship that is bound round with that heavy mass of iron, can never be a lively vessel calculated for ocean navigation. If the 600-pounder is a gun that will stand and will fire shot of that kind, we may save ourselves a great deal of trouble in going into all these investigations about the iron protection for vessels.

What we have to find out now, is that which would be safe for a vessel, and which would make the least resistance for gentlemen of that size, and let us give them every facility to go through; we will pull off our hats to them, and think ourselves very happy if they walk off without doing us any mischief; but as for adopting any kind of protective means against shot of that size it is useless; and I trust the Government will go on, and by every possible means encourage the manufacture of guns of that size, and let us for the present lay upon our oars, without building any more of these vessels. If we go on with these guns, and if the American guns are capable of going through our armour-plates, then, of course, common sense points out that it is utterly useless to go on increasing the thickness of the plates, because, under the most favourable circumstances, armour-plated vessels can never be ocean cruising vessels; they will never be fit for it, although they may do a great deal of service under favourable circumstances. As long as you could make the ship invulnerable to shot, it was an enormous advantage, but take away invulnerability from the ship, and the armoured ship sinks to a very low comparison indeed with the old wooden ship. All we have to look to, is to endeavour to make ships uninflammable, put these large guns on board, and then we must endeavour to find out the forms that will be the most convenient to carry them.

Major-General Boileau, F.R.S.: I wish to ask one question of Captain Harrison. I want to know whether in the experiment tried last Thursday at Portsmouth, with the ordinary cast-iron, or with the crucible cast-iron, or with Price's patent cast-iron shot—they did not all break up after they struck the ship's side?

Captain Harrison: There were two of them fired from the 100-pounder smooth-bore; one fell into the sea, and we could not tell what state it was in; but the laboratory shot remained in the plate, about three-quarters of it was in; we took it out of the plate, and found about three-quarters of the shot intact sticking in the plate.

General Boileau: The fact is, then, that a cast-iron shot has been produced which has passed through an armour-plate without breaking.

Captain Harrison: It did not pass through; it drove pieces of plate in front of it. When the shot was taken out, the depth that it had penetrated into the side of the ship, was just over six inches.

General Boileau: That is more than the thickness of the plate.

Captain Harrison: That is more.

General Boileau: The plate was pierced through, and the shot was not broken; that is a great step gained.

Captain E. G. Fishbourne, R.N., C.B.: I have to complain of the experiments, not in the same direction as Admiral Halsted, but just in the very reverse. He is asking for explanation of various circumstances that have been alluded to by Captain Harrison. They may be multiplied amazingly; the difference of strength of powder varies 20 per cent., and the difference of the effect of the shot, as a consequence will at once account for the alleged discrepancies. Then there is the circumstance of the striking on the edge of the plate, for unfortunately you cannot have ships clothed without having edges to the plates; and so you must accept it as a fact, that if the shot goes through the edge of the plates, when they are on the ship's sides, the ship is rendered as sinkable as if the shot had gone through the centre of the plate. But what I complain of is this, that we are continuing a series of experiments, costing a great deal of money, that will have to be gone over again when we get guns strong enough to bear sufficient charges. I want to know why the old 68-pounder, 112 cwt. gun, has not been fired with its ordinary charge? As I have said before, and as has been repeated to-night, it has been "how not to penetrate plates." We have been using small charges, in order to accommodate those small charges to the bad guns previously made, and which were to be palmed on the public. That is the history of the matter; and so now they say one-quarter the weight of shot is the proper charge. Will any enemy say:—"The English people are firing charges of only a quarter of the weight of the shot, we must be transcendental like them, we also must be scientific, and bring our charges down to one-fourth." Why should we continue to act as if we believed such nonsense? Why go on in this way? The problem is, that there are certain plates to be pierced; we should for this burn as effective, and as much powder as the gun will bear, for that

purpose, and it is useless to make experiments with small charges and bad powder. The French 30-pounder, that is the counterpart of our old 32-pounder, burns 35 lbs. of powder, and we are firing our 68-pounder with 16 lbs. of powder. What is the result? Why, they penetrate 5½-inches of plate at 1,097 yards with shot three diameters long, and which will admit a very large bursting charge. You have only to improve our 68-pounder, and you can imagine what will be the result. I must differ from Sir George Sartorious, when he suggests the propriety of making more 600-pounder guns, that in all probability won't last. Either they expand in the bore, or the shot jambs after the sixth round. There was a great fuss about the shot having gone through 4½-inches of plate, though the gun cost £3,800, when the French gun, only a 30-pounder, costing, say, £100, sent its shot through 5¼ at 1,097 yards. I protest against these experiments, and say that we ought not to be having experiments of this half-and-half kind. The problem, as I said before, is to penetrate the ship sides with the smallest gun, whatever thickness of plate, whether 5, 6, 7, or 8 inches. The result of which would be, that you could have cheaper guns, and a greater number of them. I am not an advocate for small guns, and never was; but there is a medium gun, the size of which you cannot exceed without disadvantages. I quite concur with Captain Selwyn, that the time has come when we must give up the idea of having plated ships as *the rule*. The plates are great incumbrances; they involve a reduction of speed, a reduction of guns, and a reduction of every good quality. I am satisfied that the ships will be very bad seaboats, I mean to say they will be comparatively bad men-of-war. You won't be able to fire with any degree of accuracy; so while you are reducing the number of your guns in one direction, you doubly reduce them, because you reduce their effectiveness. I think there ought to be experiments to ascertain what they are really worth. I do not think myself that, as vessels for guns, they are worth much; and I think for the purpose of experiment you can fairly judge them, not absolutely, as Admiral Halsted wants, yet we can satisfactorily measure what thickness of plates will be penetrated, when we get a gun which will give a sufficiently high initial velocity.

Rear-Admiral Sir Edward Belcher, C.B.: I have very few words to say upon the subject, and I do not know whether it would be fair to go on with this discussion, because I really think it is not on Capt. Selwyn's paper. But we have one thing to consider, viz., that we have many wooden ships abroad, and we have many officers commanding them who would have to meet these armour ships. I think the question, as Admiral Sir George Sartorious has suggested, is how are we to fight with the ships that we already have? I am perfectly satisfied that there are many officers in the service who would have no hesitation in one of these wooden ships, if she had speed, in making a very good fight with the armour vessels; and I am perfectly satisfied that one of these vessels well handled would, even with her weight of wood, walk over one of these iron ships, and put her under water.

The Chairman: If no other gentleman wishes to make any observations, I would invite Captain Selwyn to say anything he likes in reply.

Captain Selwyn: I had hoped to have heard some observations from the authorities present confirmatory of the facts I have advanced, as I did not fight the gun question so much as the question of decay; and with respect to that I have not heard any observations at present.

The Chairman: I would only say with regard to your electric experiments, that the actual question of the corrosion of the metal would be more satisfactory than experiments made with such delicate instruments as these. It is quite true you cannot take any two parts of the same bar without getting a deflection, if you use so delicate an instrument as that. An experiment showing the actual corrosion taking place would be more satisfactory.

Mr. Reynolds: If a very slight interruption is not out of place, perhaps it may not be uninteresting to mention I have just seen the "Rainbow" steamer lying at London bridge. This is the first iron steam-vessel that was built, between 20 and 30 years ago. She is now in good order; and I, therefore, think that is the best answer to the theory respecting galvanic action.

Captain Selwyn: If you please I will take the speakers in order as they occur. Admiral Halsted made a very strong fight for a stronger target.

Admiral Halsted: For a true target.

Captain SELWYN: I did not say by any means that these were results on which we could depend in combating with such iron-clads as those in the diagram before me. I said merely that a man seeing that those experiments had been made, and had produced the results which we have here in our table, seeing that those experiments have been made with such bad guns, and with such bad powder, and such bad shot, I would say there was a probability of good guns, good powder, and good shot being made which would do as much as we have got to do. I said that they could be made, because I know that the metal at our disposal—I do not say the armour-plates at present—but the metal at our disposal has been efficiently used in guns, and can be still further developed. That steel, as it bears a tensile strain of 63 tons to the square inch as against 25 tons, is better worth trying than a metal which never could have given you more than 25 tons; for if it could have done so, I think the experiments on which we spent so much money might have proved it. That metal, I must observe, has not been recently placed at our disposal. We have not been offered steel now for the first time; it has not now been brought forward as a material for shot. We might have had it three years ago just as well as at this day; and we certainly ought to have tried, if we lay claim to being scientific men, the experiments first with the best material, not with the worst. I speak principally of steel as affording a means of diminishing bulk and increasing strength in the bow and the bottoms of ships. Now, it has been tried for ships. It has answered for ships; ships are running, small vessels I admit, but they are now running with the steel in their bottoms; and except certain blistering and other symptoms, which I refer principally to galvanic action, there has been no great complaint of them, other than a degree of elasticity, which made it unpleasant to put a glass of wine on the table. That might easily be conquered by a better arrangement of the construction with a view to that elasticity; and I complained principally, not that we had not steel in its full perfection now, but that nobody had tried whether it could not be brought to its full perfection for this purpose. Nobody knows at this moment whether steel, changeable as it is by the most minute variations of ingredients, by the one per mille of phosphorous, by many other chemical ingredients which escape us in the fumes of the furnace, but which are now being considered at their due value for the first time; it is because such knowledge exists, and has existed for some time past, that I think the experiment ought to have been made in steel and alloys of other metal as much, if not more, than have been made in wrought-iron, cast-iron and other inferior materials. Captain Harrison attacked the question of iron-plates, as if I had been speaking of steel armour-plates. I did not speak of steel armour-plates at all. I spoke of Mr. Bessemer enabling us to carry 9-inch armour-plates by the use of steel in the hull of the ship, which is a totally different thing. I cannot understand what prevented our attention being given to the subject in this way, as I cannot understand why a private individual could conduct experiments which go *gradiatim* towards their object, and why the Government could or did not do so. Mr. Vickers, who is well entitled to speak about steel, tells us at once that the very first thing he did was to resort to the experiments which I suggested, though not in a similar form; but I do say that by putting plates of steel and iron with their proper backings under a steel hammer or a drop, you do get a valuable series of experiments, which would not cost much, and which men of business or science would make, and which, if Mr. Babbage or Mr. Gravatt had been on a commission, they would certainly have orced on our attention as mathematicians and engineers. I do complain that these experiments are not made, and that if I wish to seek information as a scientific man, I cannot go and take tables, on the question of resistance to impact, of the different metals and woods, as I could take tables on any other property of these woods and metals. £36,000 a year spent on experiments, and yet we cannot get such tables as these! I have the very greatest respect for Admiral Sartorious' conclusion on almost every point; but I must differ from him in thinking, as he seems to do, that because a ship carries armour, therefore she cannot be an ocean steamer. I think our experiments on the "Warrior" teaches us that although there are certain objections to them, yet that they do make very efficient vessels. We get 14 knots out of the "Warrior," and if she were thoroughly protected, I should not find much fault with her qualities at sea. She rolls badly, but perhaps that is the consequence of stowage

and various other things, which may be corrected; but I do not think it, by any means, an impossibility for a vessel carrying nine inches of armour to do well as a sea-vessel. We have not succeeded yet it is true, but there is a good old principle which I think none of my naval brethren will dissent from, which is, "Try it again." Now, uninflammability is, of course, one of those things which we should all seek to gain, and if obtained by some such compound as Bielefield's, it may meet in a measure the question of outside coating to armour-plates also. I am perfectly certain that by whatever means we may reduce the velocity of the impact which first takes place on the armour-plate, if those means be at all feasible they are worth considering. I know a great deal of attention has been given to that point, yet I think that with a mixture of metals, having different qualities in our plates, we may get a great deal more done than we have yet succeeded in getting. I long ago pointed to the fact that for the measure of penetrative power a lead target, which would not be a very expensive one because a great deal of it would be recoverable and refusable, would be most serviceable—would give a measure of penetration which we have not yet had. I confess I like those scientific results which remain for us, which do not consist in firing shot that cost £50 against a target costing £5,000, and then triumphing over the destruction of both. What Captain Fishbourne has said I so fully agree with, that I will only notice one point of dissension. He does not concur *with me* in doing away with armour-plates; but he concurs with Admiral Sir George Sartorious. Sir Edward Belcher said I was undergoing an attack which, as Admiral Halsted said with respect to the "America," I was not prepared for. On the subject of guns I did not advance many things, only that better guns could be made, therefore I think I may thank him for his remarks. I had prepared a Table (see Appendix), thinking these experiments were of considerable importance, just to refer to, and the extraordinary fact is, that I see some people who were present at the experiments, and who seem to have noted them, and who believe there was no penetration at all. Now, that that should be the case, as you see here with the 4½-inch plate the depth of indent is 7 inches, and yet there should be no penetration, I confess myself utterly unable to conceive.

Captain HARRISON: No penetration of the ship.

Captain SELWYN: We have heard that the plates were on their trial, and not the ship.

Admiral HALSTED: When a man says plate he means necessarily the ship.

Captain SELWYN: There certainly was penetration there, and the gun had a very small mouthfull to do it with. With regard to the question of electricity, and the proof of what I have stated, not being important, I can scarcely admit it. It may be true that in one ship, which has been long in existence, the rivets may not have suffered. There you must seek the occult causes which prevent the usual action of the galvanic current.

Captain FISHBOURNE: There is no proof that the rivets did not suffer.

Captain SELWYN: The gentleman who spoke supposed because he saw a vessel still in existence, one of the oldest iron vessels, that there was no galvanic action to produce corrosion. I am not speaking against iron vessels, but merely that if we make an iron vessel of 6,000 tons, costing half a million of money, it is worth while to look into the causes which may promote or retard their decay, no matter whether it be done for the purpose of a man-of-war, or for the purposes of the Australian line, which we hope to see established by the use of twin-screws. It is a point which must be attended to, and it is of the very first importance, and when it is understood no such results will take place, as were evident in the "Harbinger," without anybody being able to overcome or even account for them. No scientific man—though I can scarcely claim to be a scientific man, yet I hope some day to obtain that position—no scientific man can bear to see a thing going on for which he cannot find the reason; still less can he bear to see an object over which he has spent much time and much thought decay, without the power of arresting such action, because he has failed in his scholarship with nature. I do think, therefore, that the inquiry is of some value, and that it may be profitably further pursued. The case of steel vessels, as I remarked, will bring that more strongly home to us, if we are to use steel with the view of getting lightness of structure and with the view of carrying the weights whi ch we have to carry, then it is worth while to consider how we can arrest the decay, which might otherwise prevent our using so good a material.

TABLE *of Experiments on board Gunnery Ship "Excellent," 24th and 25th February*, 1864.

Nature of Gun.	Number of round.	Charge.	Weight of Shot.	Nature of Shot.	Range.	Thickness of Plate.	Diameter of indent.	Depth of indent.	Remarks.
		lbs.			yards.	inches.	inches.	inches.	
Wednesday, 24th Feb. 68-pounder Smooth Bore ..	..	16	68	Cast iron service.	..	4½–6	..	1½	Shot all broke up.
Thursday, 25th Feb. 100-pounder Smooth Bore. Weight 6 tons, 9·22 bore	1	25	100	Laboratory cast-iron	200	Brown 4¾	10	6½	Shot destroyed.
" "	2	"	"	Price's Crucible iron	"		"	7	" "
" "	3	"	"	Steel	"	6	..	7·12	Knee started, two planks broken.
" "	4	"	"	Steel	"	Cammell's 5½	..	4·62	
" "	5	"	"	Steel	"	"	..	6·42	
" "	6	"	"	Steel	"	6	..	6·32	
68-pounder Smooth Bore, 95 cwt.	7	16	68	Wrought iron, case hardened	"	Brown's 4½	9	2½	
"	8	"	"	Steel	"	"	8	4½	Stuck in plate.
" "	9	"	"	Steel	"	"	..	4·1	Shook out previous shot.
" "	10	"	"	.. ..	"	"	..	..	Struck lower edge of plate; went right through bottom.

Evening Meeting.

Monday, March 21, 1864.

Lieutenant-Colonel T. ST. LEGER ALCOCK in the Chair.

NAMES of MEMBERS who joined the Institution between the 7th and 21st March:—

Hore, E. G., Captain, R.N. £1.
Talbot-Harvey, W., Major, 1st Middlesex Engineer Volunteers, £1.
Liddel, W. H., Commander, R.N. £1.
Perceval, H. L., Lieutenant, R.N. £1.
Pooley, Henry, Captain, 2nd Cheshire Artillery Volunteers, £1.

THE INFLUENCE OF THE PRESENT KNAPSACK AND ACCOUTREMENTS ON THE HEALTH OF THE INFANTRY SOLDIER.

By W. C. Maclean, Esq., M.D., Deputy Inspector-General, Professor of Military Medicine, Army Medical School, Netley.

Mr. Chairman and Gentlemen,—I purpose this evening to call your attention to the influence of the present knapsack and accoutrements on the health of the infantry soldier.

Whatever may have been the case in times past, it is certain that everything bearing on the health and happiness, the moral, and physical well-being of the soldier, is now a subject of anxious consideration to the authorities, and of interest to the community at large.

After much careful inquiry into barrack and hospital accommodation, including the important subjects of ventilation, drainage, and surface space, very considerable improvements have been carried out, with the results of diminishing sickness and mortality in a very remarkable manner. Increased attention to clothing, food, moral, and intellectual training, and wholesome recreation, has gone hand in hand with the other improvements, and materially contributed to the end in view.

Among the improvements just mentioned, few were more imperatively called for than those affecting clothing. If time and the occasion admitted, it would not be a difficult task to show, that for a

long period of time the inventive genius and good sense of this country were not seen to much advantage in military costume. The "follies of the wise" have often been conspicuous in the clothing and equipment of our soldiers. The generation familiar with heads laboriously soaped, powdered, plastered, and pigtail-tied, has only just passed away. The satirist who sang—

> "God bless the Guards, tho' worsted Gallia scoff;
> "God bless their pigtails, tho' they're now cut off,"

has not long disappeared from the clubs of London.

It is only within the last few years that any difference worth naming, was to be seen in the dress of the British soldier in Calcutta, and one quartered at Chatham.* A very few years ago I saw a batch of unhappy recruits learning their drill at Arcot, the hottest station in the hot Carnatic, buttoned up in red jackets, lined with stout serge, that had been served out to protect them from the cold of the English Channel.

The great bulk of the British army embarked for service in the Crimea, clothed in tight-fitting coats, the skirts of which had been pared away until nothing remained but a ridiculous appendage, fondly imagined by tailors to resemble the tail of a swallow. We still see these garments in Monmouth-street, and on the persons of deputy-lieutenants of counties, on occasions of state. In the museum at Netley, we have a collection of military head-dresses, most wonderful to look at. Yet they were very dear to their contrivers, and—in another sense—to those who had to carry them on their heads in all climates, from Canada to Cawnpore. Most of them, I have no doubt, are familiar to many gallant officers present; they are old acquaintances of my own, for I may truly say I have seen nearly all of them "Dance into light, and die into the shade." We preserve them for the wonder, if not for the admiration, of generations to come. Then we had the leather stock, we all remember it well; how long it stood its ground, how hard it was to get rid of; and I have no doubt that, like myself, some of my audience are acquainted with a few elderly friends who cherish the memory of that garotting apparatus to this day.

Forgive this retrospect at past errors; trivial, ludicrous even as some of them now appear, they were each in their time and degree causes of suffering, sickness, and premature death.

If we have made mistakes, let us not be ashamed to own them, and let careful study teach us to avoid them for the future. On my appointment, three years ago, to the chair of military medicine, in the Army Medical School, I was placed in a position where I could study on a large scale the chief causes which influence the health of the army. As at Fort Pitt formerly, so now at Netley, the invalids from all parts of the world may be said to pass in review before the

* Professor Longmore assures me that the tunics and trowsers issued to his old regiment in Bengal, during the mutiny, were heavier than those worn in Canada.—W.C.M.

medical officers of that great establishment, who have thus an opportunity of examining men who have served in almost every region of the globe, and observing on their persons the effects of service in various climates, and the influences hostile to health to which they have been exposed; and while it is the chief duty of the Professors of the School of Military Medicine to teach the young medical officers the many valuable lessons derived from such an immense field of observation, it is no less their duty, from time to time, to give to the authorities such information as may lead to improvements calculated to promote the health and happiness of the soldier, to diminish suffering and mortality; to lessen cost, and promote efficiency. It is because I conscientiously believe that the subject to which I am about to call your attention this evening has important bearings in all these directions, that I have determined to lay it before the members of this admirable Institution, convinced that nowhere could I find an audience more capable of understanding the great practical importance of the inquiry, or more interested in its right solution.

I had not been long in the position I have the honour to fill in the public service, before I became profoundly impressed with the vast losses sustained by the prevalence in the army of consumption and diseases of the circulatory system, that is, of the heart and great vessels. Within the last three years, excluding those who die in regimental and depôt hospitals, and those of the Household troops (I exclude all invalided in Ireland, of whom we at Netley see nothing), no less than 1,344 men have been lost to the service from consumption alone. Now the causes in operation tending to produce this enormous and costly loss are many and complicated.* That the present accoutrements and knapsack, interfering as they do with the free play of the important organs within the chest, exert an important influence in this direction, I do not doubt; but as the proof of this would lead me into details, and involve many points of inquiry not suited for discussion here, I shall not go further into it on this occasion, but will direct your attention to another source of inefficiency, which can be more directly traced to the *mischievous constriction* to which we subject the chests of our soldiers at the time we demand from them the *maximum* of *exertion*.

Between the 1st of July, 1860, and the 30th of June, 1861, 2,769

* A very general impression prevails that the recommendations of the Royal Sanitary Commissioners as regards the amount of cubic and superficial feet per man in barracks has been universally carried out. This, however, is far from being the case. The home regulation is 600 cubic and about 60 superficial feet per man, but even this *minimum* is rarely enjoyed by the soldier.

In Chatham the average cubic space is only 450. In hot Gibraltar the Barrack Commissioners report that no fewer than 3,617 men have under 450 cubic feet each, and 5,253 have less than 40 square feet each. While such a state of things exists, we cannot be said to have taken a single step to mitigate, much less remove, what is certainly the master sin of our whole system, viz., overcrowding in barracks.

According to General Morin, the reporter of the commission ordered to determine the ventilation of the Palais de Justice and the new theatres of Paris, as quoted by Dr. Parkes, to keep the air pure there must be supplied—

In barracks, by day, 1,060 cubic feet per head per hour.
" by night, 2,120 " " —W.C.M.

men were discharged the service at Fort Pitt; of these 445 (or 16·07 per cent.) were under 2 years' service; and of these 445 discharges, *heart diseases* made up 13·7 per cent. From the 1st July, 1861, to 30th June, 1862, 4,087 men were discharged the service; 569 of them (or 13·92 per cent.) had less than 2 years' service, and of these, 14·76 per cent. were lost to the service from *heart diseases.*

From the date of my assuming charge of the medical division at Fort Pitt, in April, 1861, to the end of last year, no less than 883 cases of diseases of the circulatory system—in other words a number nearly equal to the strength of a battalion,—have passed under my observation, and been lost to the service, and this from one class of disease; the great bulk of the cases being young men returned to the civil population (that is, cast upon their parishes), and incapable of earning their bread in any active employment. The pension allowed to such short service men is but a pittance, and that pittance is granted only for a limited period. Let me remind you again, that in the figures I have given, the invalids of the Royal Artillery, the Guards, and the troops serving in Ireland, are not included; they were discharged without being seen by us at all.

Surely, gentlemen, you will agree with me, after hearing a statement so startling, that it behoves us to look narrowly into a question involving such an amount of suffering, costly invaliding, and inefficiency, with a view to the adoption of a remedial measure.

Before I address myself to an examination of the accoutrements and knapsack, and show the evils they induce, I must advert for a moment to three causes, which are supposed to exercise a disturbing influence on the organs of circulation, and to act either as predisposing or exciting causes of disease of the heart, viz., rheumatism, intemperance, and excessive smoking.

Rheumatism affects the fibrous structures of the frame; these structures enter into the formation of the delicate valves of the heart, and these valves are apt to suffer from this disease, to have their mechanism injured, and so to interfere prejudicially with the working of the heart—the central moving power. Now, many cases of heart disease can be traced to this cause, and soldiers, from the very nature of their calling, are of course much exposed to rheumatism; but, making a fair allowance for this, particularly among old soldiers, an immense number of cases remain that cannot be accounted for in this way. A vast number of the young soldiers discharged the service for heart disease have never suffered from rheumatism at all.

With regard to intemperance, it is undeniable that the presence of alcohol in the blood exercises a prejudicial influence on the heart and great vessels, as well as on other organs, but here we have the same difficulty to meet, viz., that a large proportion of our young lads are lost to the service from heart disease ere they have contracted the baneful habit of spirit drinking.

Nor do I deny that excessive abuse of tobacco may in many cases result in an irritable condition of the heart, incapacitating a man from much exertion; but I think there is no proof that young soldiers smoke more than other classes of the population.

Is it that soldiers are called upon to make greater exertions than the labouring and manufacturing classes? Doubtless the soldier has at drills, marches, and field-days to put forth considerable exertion; but is this more than, or so much, as we see daily done by our "navvies," and others of the labouring classes? I think not. We must look, then, to the different conditions under which the two classes work. A labouring man or mechanic, when he addreses himself to his work, lays aside every weight, and every article of dress that can in the slightest degree interfere with the free movement of his chest and limbs. In like manner, the sportsman, or the Alpine tourist, adapts his dress to the work in which he is engaged. But the soldier on the other hand, is called on to make the severest exertions, at the utmost possible disadvantage as regards the weight he has to carry, the mode in which he has to carry it, and the entire arrangement of his dress and equipment.

The function of respiration in health, when we are not unduly exerting ourselves, is carried on with so much ease and regularity, that we are hardly conscious of the action of its complicated mechanism; we draw air into our lungs and expel it without an effort. It is only when we experience in our own persons, or witness in others, the effects of even a momentary interruption to the due performance of this function, that we become aware of its vital importance to our very existence. Three minutes' total suspension of respiration, and we die. So essential is respiration to existence, that it is placed under the control and guidance of a part of the nervous system apart from the will, and it is only when the function is interfered with by disease or excessive exertion, that the assistance of muscles, under the direct control of that will, is called in to aid us in the struggle for the free admission of that air, without which we die. Let us glance for a moment at the chest and its contents.

I have here the framework of the torso or trunk. Within the elastic walls of the chest are placed the lungs, the heart, and the great vessels leading from it, and these fill it equally in all its alterations of size; it is so contrived, as to shield these vital parts from injury (save of course from injury of an extreme degree), and yet to give them that free play, without which their functions cannot be performed. You observe its construction—consisting of the spinal column behind, itself made up of many separate pieces, with an elastic fibro-cartilaginous cushion interposed between its separate parts, represented artificially here, the breast-bone in front, and the ribs, or osseous arches, enclosing the chest. Note that each rib has a cartilage of prolongation; these are of great strength, and very elastic. By their means, the seven true ribs are connected directly to the breast-bone, those of the remaining ribs, merely to each other. You cannot fail to observe that there is here unequivocal evidence of a provision for motion. Let us look now at the movements to which this anatomical arrangement points.

During inspiration, the collar bones, first ribs, and through them the breast-bone and all the annexed ribs, are raised; the upper ribs converge, the lower diverge, the upper cartilages form a right angle with

the breast-bone, and the lower cartilages of opposite sides, from the seventh downwards, move further asunder, so as to widen the abdominal space between them, just below the point of the breast-bone; the effect being to raise, widen, and deepen the whole chest, to shorten the neck, and apparently to lengthen the abdomen. During expiration the position of the ribs and cartilages is reversed; the breast-bone and ribs descend, the upper ribs diverge, the lower converge; the upper cartilages form a more obtuse angle with the breast-bone, and the lower cartilages of opposite sides approximate, so as to narrow the abdominal space between them, just below the point of the breast-bone; the effect being to lower, narrow, and flatten the whole chest, to lengthen the neck, and apparently to shorten the abdomen. During inspiration, the movement of the lungs and heart is downward.*

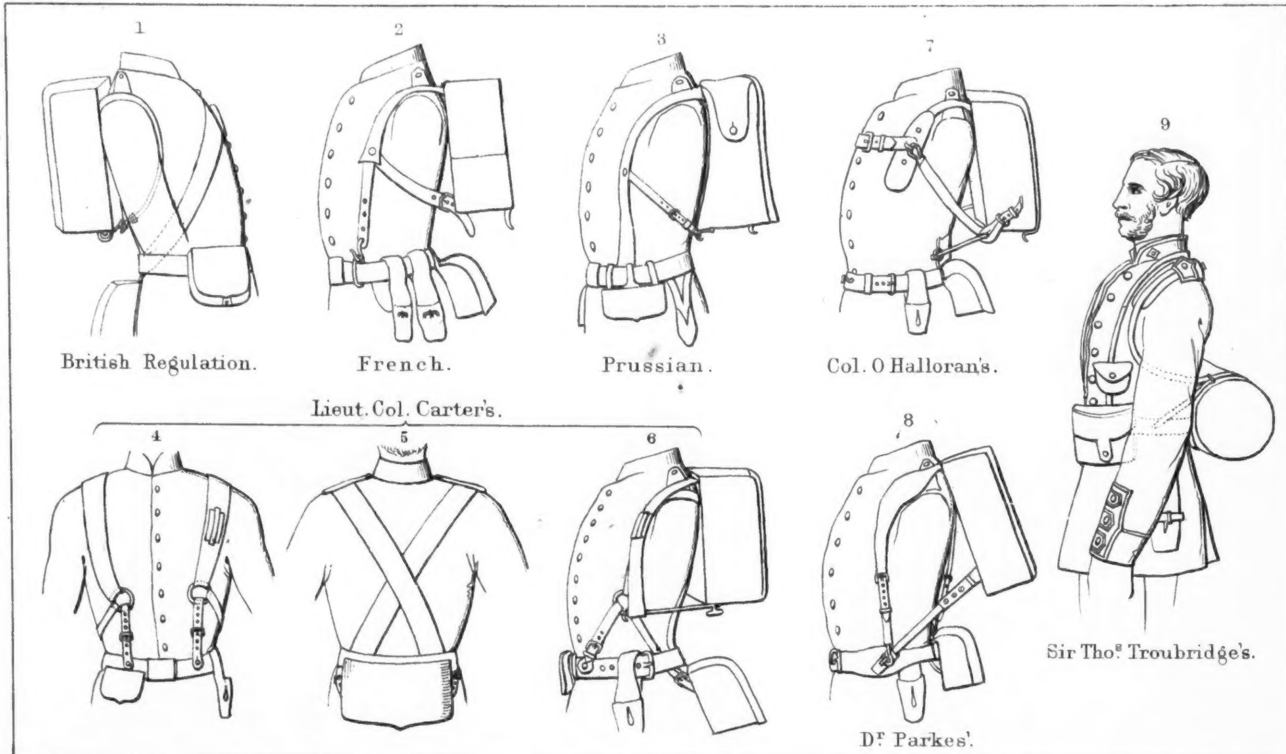
Let us now inquire whether there is anything in the mode in which the soldier is weighted and accoutred likely to interfere with these natural movements more or less at all times, and particularly when making severe exertion. And here I must take the opportunity of saying that this question has been very carefully examined by the professors of the Army Medical School; and, after mature consideration and inquiry into the whole question, we have arrived at the conclusion that the present accoutrements are highly injurious to the health of infantry soldiers, and have a large share in producing many affections of the lungs and heart common among them; in fact, so impressed have we been with the importance of the subject, that, in conjunction with Major Deshon, 2nd Depôt Battalion, an officer who has paid a great deal of attention to these points we made two reports on the pack and accoutrements of the infantry soldier, which reports were presented to the General commanding at Chatham. From these reports I shall quote largely in the course of the following observations. It will perhaps be well for me to mention that two great military nations, France and Prussia, have experienced the inconvenience of a faulty system of accoutrements to such an extent that they have introduced improvements intended to relieve the soldier from injurious pressure upon his chest and abdomen, and to interfere as little as possible with the free action of his muscles and organs,

The weight of the British soldier's clothes, great coat, field kit, and canteen, with 60 rounds of ammunition and 75 caps, havresack, bayonet, rifle, and sling, pack and straps, pouch, &c., &c., is 48 lbs. 5¼ ozs.

If the soldier has to carry his blanket, as in the field, with rations for three days, and his water-bottle, an addition of 12 lbs. is made, making in all 60 lbs. 5¼ ozs.

Let us now look a little closer at the regulation pack. In the diagram before you (Plate x., Fig. 1) is a drawing of it. You cannot fail to see that the whole weight of the pack is thrown on the

* Vide Sibson's Medical Anatomy.—Here Dr. Maclean showed a figure in outline, displaying the extent of these movements, and also a skeleton of the trunk, showing its framework, &c.—Ed.


1
2
3
7
9
British Regulation.
French.
Prussian.
Col. O Halloran's.
Lieut. Col. Carter's.
4
5
6
8
Sir Thos. Troubridge's.
Dr. Parkes'.

J.R.Jobbins.

straps passing under the arms; the pouch and a small packet for caps are carried on the belt, which runs diagonally across the chest, and the bayonet and ball-bag are carried on the waist-belt; the belts are therefore so disposed as to press most injuriously on the chest; the cross-belt, stretched by the great weight of the pouch, impedes the forward movement of the ribs; the waist-belt hinders the expansion of the inferior false ribs, which, as we have just seen, in the state of unrestricted movement, is very great; and the pack-straps press on important muscles, arteries, veins, and nerves to a degree which only those who have carried the loaded pack can appreciate. The weight, especially when the great coat is strapped on, falls to a great extent behind the line of the centre of gravity. Now these objections are by no means merely theoretical; soldiers universally complain of the sufferings they endure from the pack and present accoutrements, and if you closely question the sufferers from heart disease, you will find how closely they connect their complaints with these belts and packs.*

It is certain that at no period was the pack more worn that at present. I find that it is worn at least once a day on regimental parade, and on all brigade and field days at all the camps in this kingdom. I have been at some pains to ascertain from regimental medical officers the effects observed on the men, particularly on field days. Some do not appear to have paid much attention to the subject, but the majority seem alive to the ill effects of the pack and accoutrements.

Many men fall out in a state of extreme distress, and many surgeons assure me that nothing but a strong feeling of *esprit de corps* prevents many more from doing so. In all well-disciplined regiments the practice of falling out at drill or on the line of march is discouraged, and men will bear and suffer much, rather than incur the imputation of being "soft"—some, to my own knowledge, have worked on through a field day, and have died rather than give in. An instance of this occurred at Aldershot on a field-day last summer.

In the first of the reports on packs submitted for the consideration of the General commanding at Chatham, by the professors of the Army Medical School, the following were the general principles insisted on:—

1. To distribute the weight, as far as practicable, over the body.
2. To bring the weight, as far as possible, within the line of the centre of gravity.
3. To allow no pressure on the principal muscles, nerves, arteries, or veins.
4. To avoid most carefully all impediment to the fullest expansion of the lungs, and to the action of the heart.

This rule is a cardinal one. Unless the circulation through the lungs be quite free, continued exertion becomes impossible. The commonest experience shews that the number of respirations,

* Here the Professor showed a preparation of a human heart, taken from the body of a soldier, with a white spot or corn on it, which he explained arose from the pressure and friction to which the organ had been exposed. He further stated that this "corn," rare in civil life, is the rule and not the exception in the bodies of elderly soldiers.—Ed.

and the amount of air drawn into and expelled from the lungs, is enormously increased by exertion. Late physiological inquiries have shown that the elimination of carbonic acid is also prodigiously augmented, and this is a necessary sequence of the muscular contraction. If this elimination be prevented by any interference with respiration, no amount of energy or volition on the part of the man will enable him to continue his exertion. Trainers, both of men and horses, have long been aware of this fact.

I have just shown you how impossible it is to carry out such principles as these with the regulation pack, which is constructed as if for the purpose of transgressing them all.

Fig. 2 shows the French pack, that worn by the Chasseurs de la Garde. It is secured by straps going under the arms, as in the English pack; but it is an improvement on the latter, as two straps run down from the arm-straps to the waist-belt, and so relieve in great measure that excessive pressure on the arms so much felt by our men. It approaches the Prussian pack, but is not so good; the pouch (which is small) is carried on the waist-belt behind, and there is no cross-belt whatever; the lungs have therefore very fair play with this pack, the amount of ammunition is, however, smaller.

Fig. 3 shows the Prussian pack and accoutrements. You see that they are arranged differently from any of the others. The ammunition is carried in two pouches attached to the waist-belt, capable of carrying each 20 rounds of English ammunition, and 15 of Prussian. The pack fits to the back, to which it lies as close as possible. Two broad straps pass from the top of the back over the shoulders and fall to the waist-belt, to which they are joined by two brass hooks.

Two other straps run from the lower part of the pack and join these shoulder-straps, so that the pack is quite steady, and its weight is counterbalanced by the pouches in front.

This pack is much superior to ours; it exerts only moderate pressure on the lungs, and none on any muscles or vessels; the weights are close to the body, and the weight of the pack falls within the centre of gravity. The arms have full play. In the trials conducted by us, this pack was invariably preferred by the men to our own, although it was not rated so highly as others.

Figs. 4 and 5, show front and back views of Lieutenant-Colonel Carter's accoutrements. Fig. 6, side view of accoutrements and pack. The pack is supported by two straps passing over the shoulders and hooking on to two iron rods, which project forward from the lower end of the pack; the front of the pack is concave, and is made of wicker work; its weight is very great, and it is altogether too large.

It is, however, a vast improvement on the regulation pack. It is borne on the shoulders, and does not press at all on the lungs, or upon any muscles, nerves, or vessels; the arms are quite free. The pouch, which is a large one, hangs away from the body too much. It is, however, carried easily. The belts are too heavy and complicated. In our trials the men reported favourably on this pack, all who tried it declaring it to be an immense improvement on the regulation pack.

The next is Berrington's pack, adapted with Colonel Spiller's rods by Colonel O'Halloran (Fig. 7). The belt represented in this drawing as passing across the chest is done away with in Colonel O'Halloran's improvement pack.

It is carried by means of two flexible steel plates lying in front of the chest, and having attached to them two straps passing from the lower end of the pack beneath the arms. Two rods, with a broad strap between them, support the lower part of the pack against the small of the back; no muscles or vessels are pressed upon, and the arms are perfectly free. The weights are tolerably close to the centre of gravity. With this pack, the pouch and bayonet are carried as in the regulation pack. The steel plates were thought by us an objection to this pack, as by their breadth they, in some degree, press on the ribs in inspiration. The pack, however, in our trials was favourably reported on.

A pack contrived by my colleague, Dr. Parkes (Fig. 8), was also tried. The principle of it is to throw the weight in part on the hips, by means of two straight iron rods running from the bottom of the pack, and fitting into two sockets in a hip-belt. The principle of this pack is sound, but there is great objection in this, as in the others, to the iron rods, which, if broken on service, cannot easily be replaced. They are also dangerous, for if struck in action the fragments would almost certainly be driven into the body of the wearer, or that of a comrade in the ranks. The conclusion come to by us, after a careful examination of all these packs, and carefully conducted trials with them all, was, that the regulation mode of carrying the pack was the worst of all; but good as some of the proposed plans are, none of them seem perfectly to answer all the required conditions.

Lieutenant-Colonel Carter and Colonel O'Halloran were not the only officers who saw the necessity of introducing a new and a better mode of carrying the pack.

Sir Thomas Troubridge exhibited at the last great Exhibition a valise, which I now show you (Fig. 9), and on which we (the professors) made a special report to Major-General Eyre, Commanding at Chatham, an officer who has taken a great interest in this question, and who gave us his cordial co-operation in investigating it..

This pack is carried in a mode different from any of the others. A yoke, on the principle of the milkmaid's yoke, is fixed on the shoulders; from this two metal rods (of tubular copper or of steel) pass down in front of the arm-pits, which they do not touch, and are hooked behind to a round bag or valise (without any frame), which is carried on the small of the back, or just above the hips. The weight of this valise is chiefly thrown on the shoulders, but it is also partly thrown on the strong hip-bones, in this resembling Dr. Parkes'. There is not the least pressure, either on the chest or on the arm-pits.

As the valise is thus carried so low down, the ammunition cannot be carried in a pouch behind. It is, therefore, placed in two pouches in front (each intended to carry thirty rounds), and a strap passes round the back of the neck, and hooks into each pouch.

A waist-belt carries the bayonet, and keeps the two pouches steady;

the pouches thus balance one another, instead of, as in the Prussian plan, the pouches balancing the pack.

The great-coat can be carried either on the top of the valise, or in a roll over the shoulder.

On considering the mode in which the weights are distributed on this plan, it is evident that it satisfies all the conditions which we formerly enumerated as essential to a perfect system.

Not the slightest pressure is made on the lungs; no great muscle, vessel, or nerve, is pressed upon; the weights are close to the centre of gravity, and are as near the line of the centre of gravity as they can be; while the strongest parts of the body, viz., the tops of the shoulders and the hip-bones, carry the weights.

As far as mechanical and physiological principles are concerned, we see nothing wanting in this plan. The weight, in pounds and ounces avoirdupois, of Sir Thomas Troubridge's valise, with kit, ammunition, &c., is 17 lbs. $12\frac{2}{3}$ oz.

Any one who has seen the enormous weights carried by the Canton water-bearers, or the Banghy Burdars and palankeen-bearers of India, all borne on the shoulder, in such a way as not to interfere with the free play of the chest, will see that Sir Thomas Troubridge has thus hit on the right principle for carrying the soldier's pack and ammunition. We submitted this plan to a trial against O'Halloran's pack, as improved and exhibited in the last Great Exhibition.

Four experienced non-commissioned officers, and privates, after being carefully examined by me to see that they were free from chest disease, were marched eleven or twelve miles accompanied by Major Deshon, who closely watched them: they used the pack and valise alternately, and on returning, their unprompted statements were taken down by me verbatim. Without going into details, I may say that the reports of all the four men were identical: they all praised Colonel O'Halloran's pack, and thought it much better than the regulation, but they reported of the valise that it was as superior to Colonel O'Halloran's pack, as that was superior to the regulation.

The ease of breathing, the freedom of the arms, the apparent lightness of the weights, the absence of fatigue or exhaustion at the end of the march, with Sir T. Troubridge's accoutrements, were all points strongly insisted upon by these experienced non-commissioned officers and soldiers; nor did they hesitate to affirm that the efficiency of the soldier would be increased to an immense extent by their adoption throughout the service.

In conclusion, I trust that some of the distinguished officers present may be induced to inquire into this subject for themselves, to make comparative trials with the packs just exhibited, and with the contrivance of Sir Thomas Troubridge; if any can be induced to do so, and to investigate it thoroughly, I feel convinced they will find that my colleagues, and the gallant officers who have co-operated with us, have not exaggerated its importance. I am quite aware that the introduction of a new knapsack into the service would be a very costly measure; but if once the fact is established that the present knapsack is costly from the amount of invaliding it

entails, and cruel from the suffering it causes, enough will be done to warrant, at least, the gradual introduction of a better. To an audience such as this, I need hardly add, that the tendency of modern tactics, all over the world, is to rapid movements in the field, and if it is insisted on, that modern soldiers shall march and fight with their kit on their backs, it is obvious that this should be so placed, as to embarrass their movements to the smallest extent, if not they must fight and march at a grievous disadvantage.

The CHAIRMAN: I am sure Dr. Maclean will be ready to answer any question that any gentleman may wish to put, or should any gentleman wish to illustrate the subject by mentioning the results of his own experience, we shall be very glad to hear him. If no one has any observations to make, I am sure you will now join me in a vote of thanks to Dr. Maclean for the interesting lecture we have had, and for the able manner in which he has delivered it.

We will now proceed to call upon Dr. Domenichetti to begin his lecture.

SICKNESS CHARTS ILLUSTRATING DISEASES, &c., OF THE ARMY.

By R. Domenichetti, Esq., M.D., Surgeon, 75th Regt.

Mr. Chairman: I am desirous of introducing to the notice of the meeting this evening, the subject of a statistical chart, intended to illustrate the diseases of the army. This is no novel idea; it originated (so far as I am concerned) as far back as the year 1847. I may observe that I had occasion to see and inspect a chart by Captain Edwards, of the 86th Regiment, who presented it to Sir Charles Napier. It was intended to show different meteorological phenomena of the climate of Scinde, which country had just been occupied by our troops. He undertook to illustrate the rise and fall of the river Indus, the various phases of the moon, and other meteorological phenomena connected with the country. It occurred to me, that it would be exceedingly desirable to adapt the same principle to the illustration of disease, if it could be done in a simple and comprehensive manner. Accordingly I applied myself to the subject, and succeeded in my object, to the extent which you will perceive.

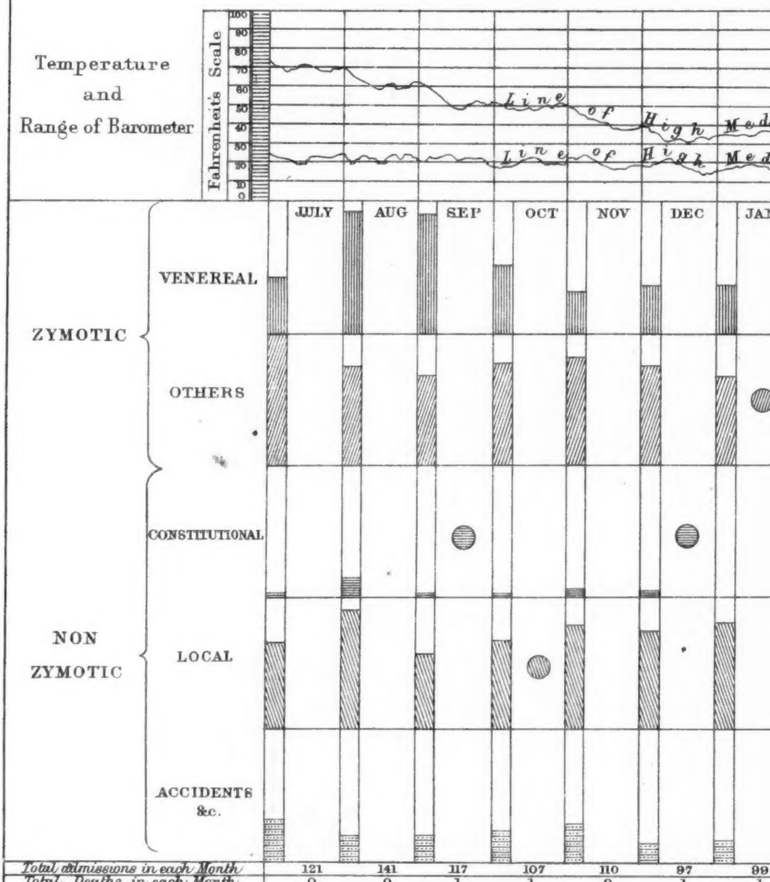
The chart to which I would first call your attention, is an Annual Chart with a simple scale (see Plate XI); these other diagrams are merely divisions of the chart, for the purpose of illustration. I will commence by showing you, in the first instance, the principle on which it is arranged. It occurred to me, that if it was possible to exhibit the various diseases of the soldier classified in some simple and acknowleged form; and to show how far the temperature, the dew point, the range of barometer, and other meteorological characters, could be embodied in the chart, and were their influence shown in the progress of any particular class of disease, a very great object would be gained.

This diagram illustrates the temperature. The curvilinear method is adopted. It must be perfectly familiar to students of statistics that two forms have been recommended—the columnar and the curvilinear. There is no doubt that the curvilinear presents some great advantages; for instance, the temperature is better displayed by that method. In the army, we are the creatures of routine, and the columnar, so far as diseases are concerned, is the preferable plan. We are accustomed to look forward to weekly, monthly, and quarterly reports, and our ideas run in a kind of groove; we are accustomed to look to these periods for denoting the progress of disease. And our returns also tend to that illustration. On that account I select the columnar plan, as being preferable.

In regard to the temperature, I have attempted to show its range

75TH OR STIRLINGSH

STATISTICAL CHART, *Showing the Sickness and Mortality in*



Explana

Scale

1 25 50

The Scale indicates the number of admissions under the various classes of Disease for the Month in the ratio of one degree for one admission into Hospital. The Circles denote Deaths according to the Class of Disease by which they occurred.

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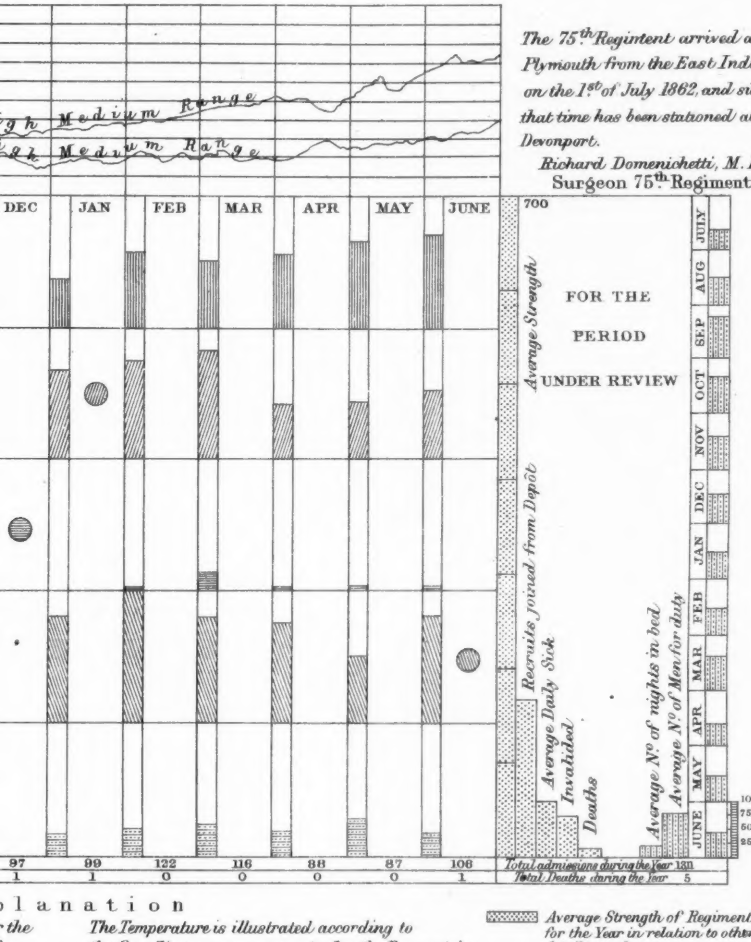
E. Edis, del. Hospital Sergeant. 75th Regt.

RLINGSHIRE REGIMENT.

Mortality in the above Corps, between the 1st July 1862, and the 30th June 1863.



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The Temperature is illustrated according to the Curvilinear arrangement, also the Barometric pressure in connection with the changes in the number of admissions.

Average Strength of Regiment for the Year in relation to other details as above.

Denotes number of Sick in Hospital on 1st of each Month, average No. of Men for duty, No. of Nights in bed

J.R.Jobbins

an outline of the Fahrenheit thermometer, as shown in the margin, and the variations in the common known way. Underneath is the dew point. The amount of rain, and other points of interest, might be shown. It was my intention to embody these different points, with the view of accounting for the progress of disease; its diminution; the phases of the moon; the direction of the wind; the amount of ozone in the atmosphere, &c. I merely throw out these hints to show how far the subject admits of illustration.

The columnar method has been followed out with regard to the classification of disease, under two heads—the zymotic and non-zymotic. I am not prepared to indorse the value of these names, because I have it from a good authority that there is a Medical Council now sitting to determine the change of medical nomenclature. I am sure it will be for the better, but in the absence of any better method I have adopted the one in vogue. Here the various classifications of disease are shown. There are columns differently coloured for the month in which they have been under review. For instance, here is a column shown by the scale to be so many degrees in height; that represents so many cases of disease in hospital. Here, again, under the head of fevers or zymotic diseases of different kinds, is a smaller column. Again, the constitutional affections still lower; and so on, denoting 217 cases, in the aggregate, under treatment on the first return day in the month of January. Those circles denote death to have occurred, and they are coloured according to the diseases of which the men died.

The great advantage of my plan, I submit, is simply this: That on a single chart may be represented the annual return of a British regiment of infantry for one year. I do not wish to bring into question the advantage of voluminous reports; but I am sure my non-professional friends will agree with me, that it is extremely laborious to pore over voluminous details, and at the end, perhaps, to arrive at little or no understanding of the subject. That has been the remark of various military authorities whom I have consulted.

When on the staff of Sir Willoughby Cotton in 1847, in India, I had the good fortune to know Sir Henry Havelock. I submitted this chart before you, to him. He, the head of the Adjutant-General's department, said, "This is precisely the kind of chart the military authorities stand in need of; we don't want accuracy of detail, but what we want to arrive at is the state of a regiment at a single glance. I see your chart is in that particular very satisfactory." And he recommended me to pursue my inquiries.

I ought to apologise to the meeting for having intruded these crude ideas upon you, but I shall be able presently to show the sanction of some high names as to the utility of this chart.

I may now go into detail in regard to the explanation of the annual chart. Underneath are figures denoting the number of diseases in hospital on the first of each month. Then there are the months during the year; and the amount of sickness and mortality are shown by these different coloured columns, graduated according to scale. Here you see the number of deaths. There were two deaths in the course

of the year. The same with the local affections. It would be interesting to watch the effect of the range of temperature, or dew points, as far as regards the progress of any particular class of disease.

It occurred to me that it would also enhance the value of the chart if a column intended to represent the strength of the regiment, say 800 men, were attached to it, and such other details as might be interesting to an officer commanding a regiment or station, *e.g.*, the number of men joined during the year, the number invalided, the number of deaths, the average number of men fit for duty. If all these points could be embodied in this chart, the commanding officer would then have in his possession all the essential particulars regarding the station or regiment. Whether this will be fulfilled from the indication in view, is for you to determine hereafter.

The same principle is also capable of being applied in another manner. Here is what is called a divisional chart. It has only lately received any share of attention from me; but it occurred to me that the same principle might be adopted on a larger scale. For instance, a general officer or brigadier, commanding a division or brigade, would be able at one glance, by means of these graduated columns, to ascertain the amount of sickness prevailing amongst the men under his command, the number incapacitated by wounds, the number killed in action. The same with the meteorological facts, which I have not noticed in this chart, but which I have indicated in the other. It is sufficient for you to follow out the idea, and see what I intend to do with regard to the system.

I will now give some sort of notice regarding the encouragement I have met with. In the year 1849, as I told you, I had an opportunity of showing the chart to Sir Willoughby Cotton and Sir Henry Havelock, both of whom cordially approved of it. I was not so successful the next year. Without being egotistical, it only amuses me to think that everybody must be prepared to encounter a certain amount of opposition in advocating any particular project, or in encountering the prejudices of those with whom he may be associated. I had occasion to send an elaborate copy of this chart to the head of my department in Scinde, expecting, of course, that it would be forwarded to the authorities. I received the following reply. The head of the department said "he had the pleasure to acknowledge the receipt of this elegant and ingenious bauble, and at my period of service he would recommend me, instead of presuming to generalise upon diseases, to attend to the individual study of disease; and in conclusion he begged to recommend me to study Abercromby on 'Intellectual Powers in the Investigation of Truth.'" This was not very encouraging, consequently the project remained dormant for a considerable time, until called into action by Lord Clyde, who saw a copy of it, and who wrote to a commanding officer of a regiment to say, that it would give him extreme gratification to see this chart and peruse it, as it had afforded him at a single glance the history of the 75th Regiment (see Plate XI), and he begged to express his high approval of it. Accordingly, afterwards Sir Hugh Rose sent for me to Calcutta, and I explained to him, as I have done here, the bearings of this chart. Since, then, some of my brother

officers have been to me with a number of the "Army and Navy Gazette," in which they saw a startling notice, as far as I was concerned. It was to the effect that Sir Hugh Rose is deserving of great credit for having adopted a new form of statistical chart, which has been forwarded to every station in India. This was my chart, and as it has not been acknowledged, I take the opportunity of giving it all due publicity. The *Lancet* spoke well of it, but objected to the columnar mode; they gave the preference to the curvilinear plan. With regard to this objection, I may refer to other statistical plans in the army.

A French medical officer, in charge of the troops at Rome, has constructed a most ingenious and elaborate chart, which was shown to me by the head of the Statistical Department; being extremely elaborate, it occurred to me that it was rather difficult of comprehension, and required to be studied. With regard to my chart, all that I had in view was to make it simple and comprehensive to the military authorities. If it should succeed in obtaining the sanction of those in power, all that would be necessary would be, not to undergo the laborious toil it has cost me in preparing it, but simply to have it lithographed, and have it filled up by any intelligent non-commissioned officer, with the least trouble in the world. Then, in the course of a few hours, the authorities would be in possession of a chart giving all the details with regard to temperature, disease, and the other points that I have specified, without incurring the labour of reading numerous documents.

Very lately I had occasion to show my chart to General Hutchinson, Lieutenant-Governor at Plymouth, who gave me great encouragement in the matter. He wrote to me on the 17th of August as follows:—

(Copy.)

Letter from Major-General Hutchinson, Commanding the Western District, Plymouth.

Government House, August 17th.

Dear Dr. Domenichetti,

I had no favourable opportunity of shewing Lord de Grey your ingenious chart. It is most clearly arranged.

I was at the Senior Department, Sandhurst, with Sir Alexander Tulloch, and remember his drawing up some statistical returns on the same principle, graduated coloured columns, showing the comparative mortality of the several West India islands, compared with other stations. The account was published in the *United Service Journal.* Met the eye of Lord Herbert, who sent for the writer, was much pleased with him, and the interview ultimately led to Tulloch's introduction into the War Office.

Yours truly,
(Signed) W. H. HUTCHINSON.

I return the chart with many thanks.

This, it appears, met with the approval of General Hutchinson, who is a great authority in military matters and in sanitary reform, having given a good deal of time and attention to that subject.

I have also got a letter from Dr. Hadaway, who was the Inspector-General with Lord Clyde :—

(Copy.)

Letter from Deputy Inspector-General Hadaway.

Devonport, 24th March, 1863.

Dear Dr. Domenichetti,

In answer to your note of this day, I beg to state that I remember pefectly having had, while at Simla, Bengal, a statistical chart referred to me, by Lord Clyde, through the Adjutant-General, Queen's Troops, and it affords me pleasure to say that I quite recollect having given a favourable opinion of it, as a ready way of elucidating at a glance the state of health of any particular corps.

Believe me, yours very truly,

(Signed) S. M. HADAWAY,

Deputy Inspector-General.

To Dr. Domenichetti, Surgeon, 75th Regiment.

I have not much further to urge with regard to critics of the press, beyond the fact that the *Lancet* has noticed my plan very favourably. I would refer you to the number of October 17th, in which the views of the editor are given.

In conclusion I may say a few words with regard to the merit, if any, which I claim in connection with this chart. Not long ago I discovered that in the year 1837 some medical officer had undertaken to show the comparative mortality of black and white troops by means of coloured columns. These you may say are crude ideas, and not followed out to the extent that the present system proposes. It seems that Sir Alexander Tulloch has done the same, and it has been done before. But it had never been worked into a system. There are other charts, too. The Crimean war made us familiar with the columnar and curvilinear mode of depiction. These dates speak for themselves. All I say is, that in the year 1847, these little charts were but little thought of, and it was only during the Crimean war that the subject received particular attention. I think, therefore, a very fair share of originality may be due to me, so far as adapting them to diseases. I have only to thank you for your courtesy in listening to me, and I shall be glad to hear any remarks with regard to the plan that I have had the honour to introduce.

The CHAIRMAN: I am sure you will all join me in returning our thanks to Dr. Domenichetti for the explanation he has given of his very useful chart, which I think would be of great service to commanding officers. As there is little time left for discussion, I may venture to state that Dr. Domenichetti's chart, among other things, shows the prevalence of one class of diseases in garrison towns, a subject which happens to be at the present moment very much before the public. It is a subject that is very difficult to talk about, but it is one that will undoubtedly have to be dealt with. In the chart, that complaint stands in the highest line, and its prevalence renders the army very inefficient at times. The subject is peculiarly fitted for consideration by this Institution, which takes interest in every thing relating to the health, welfare, and efficiency of the two services Therefore, I think I am right in announcing that if any gentleman wishes to introduce that subject, this will be the proper and probable the only opportunity of doing so.

Dr. BALFOUR, Deputy Inspector-General: Mr. Chairman, I rise with very great reluctance to make a few remarks upon the Tables which Dr. Domenichetti has submitted. They are extremely ingenious, and I am willing to give him all credit as the inventor, because, I believe, before he brought them forward himself, he had not seen any that had been previously introduced. There are two points, however, on

which he has made a mistake, which I think it necessary to correct. The first is, the date to which he goes back as the period at which these columnar Tables were first introduced, and which, I think, he stated to be 1847. To my certain knowledge they were in use ten years before that. The second point to which I would refer is General Hutchinson's letter, in which he states that Sir Alexander Tulloch had published some statement of the kind in the military journals, which had been brought under the notice of Lord Herbert, that Lord Herbert sent for him, and that it was to that that he owed the introduction to the War Office. It happened, that in 1836 and 1837, Sir A. Tulloch and I, he then being a subaltern in the 45th Regiment, were employed by the Government in preparing a report on the health of the army serving in the Colonies. We prepared columnar tables, in which we illustrated the different diseases among black and white troops, in the different islands and stations in the West India command. That was at least ten years before the period which Dr. Domenichetti has named as the origin of this method of illustrating disease. We applied it only to the West India Report. I believe, a well-arranged table, showing the ratio per thousand illustrates the mortality at different stations, from different causes, and at different periods of the year, quite as well, in a much smaller space, and with considerably less trouble, than the method which Dr. Domenichetti has brought before us. Another objection, I think, to Dr. Domenichetti's mode, is that in preparing these columnar tables you are obliged to do the work twice. You must first do the figure work, you must add the numbers and calculate the ratios, before you can prepare your tables. The columnar tables, therefore, are merely another mode of illustrating the figure tables. They have also this great objection. If you publish a report, such as is now published annually as part of the Army Medical Department Reports, and illustrate all the classes of diseases under which the troops suffer, at all the different stations, by means of such diagrams, you must almost publish a library instead of a volume; and even if you could condense it into a much smaller space than I imagine would be requisite, the expense of publishing lithographed tables in the form of a report would be so great, —I speak with some experience—that it would materially diminish the value of these reports. The advantage of these reports I hold to be, that you are enabled to circulate very extensively information regarding the health of the army; whereas, if you go to the expense of lithographed tables to illustrate it, the book itself would cost two or three pounds, instead of four or five shillings. I think this of itself is a very serious objection. I am quite willing to admit and I feel that the tables are very interesting to look at; but in preparing reports, as we are obliged to do, including the condition of large bodies of men scattered all over the world, and keeping the different military commands and the different stations separate, I think it is a point of the utmost importance to condense our information into the smallest possible space. I am sure that any one who has been accustomed to look at figures, in consulting one of the tables, would be quite able to apprehend the subject as well as if he were to look at these columnar tables. I am extremely sorry to be obliged to make these remarks after the complimentary manner in which Dr. Domenichetti has spoken of me in his remarks.

Dr. Crawford: There is another serious objection not only to the ingenious tables of Dr. Domenichetti, but to all forms of coloured tables and diagrams; and that is, the public have no means of criticising them. With regard to disease in particular, every man knows what 150 cases of fever means, but he does not know what a square inch of fever means. I think that is a very serious objection to all these diagrams, and one that is felt by all who are not able to go to the sources of information, or to appreciate the principles upon which the tables are constructed. I do not mean to say that they are not constructed upon principles which are capable of confirmation, but I mean to say that every person is not able to understand the principles on which they are constructed.

Dr. Domenichetti: With regard to the remarks which have fallen from the first speaker, I may be allowed to mention that, with regard to dates, if I remember right, I admitted that the plan was first tried in 1837, but it was in 1847 that the first columnar chart was brought out. Then, with regard to the objection which has been raised very justly against this method of delineation, I would observe that I never

for a moment supposed that this form of chart was to supersede either written returns or figure reports. It was merely as it were an illustration of a subject, which was only imperfectly conveyed by voluminous reports and documents, which are never perused by the majority of non-professional people. I allude more particularly to the military branch of the profession, and I appeal to them whether in their various years of service in various parts of the world, they have taken the trouble to make themselves acquainted with the statistics of returns of stations. Take the blue-books of the inspectors, and I ask, how many have taken the trouble to wade through them, unless they are lovers of statistics. It will be seen that it is by means of these charts that we would assist those who are studying statistics, not to make them absolutely dependent upon them. Of course, figures are more to be depended upon than any coloured diagrams whatever. It is merely with the view of making a dry abstract subject popular, that I have introduced these charts at all. Military officers have appreciated them, and have said that they enable them to know exactly the state of the regiment, as much as they require to know, without being bored with reading documents which they do not understand.

The CHAIRMAN: If no other gentleman has any observation to make, I believe the business of the evening is concluded, with the exception of a vote of thanks to Dr. Domenichetti for his kindness in reading this paper; and we must include those gentlemen who have kindly taken part in the discussion.

Evening Meeting.

Monday, April 6, 1864.

Captain E. GARDINER FISHBOURNE, R.N., C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 22nd March and the 4th of April.

Farquharson, G. M'B., Capt. 20th Regt. H. M. Bombay, N. I. 1*l*.
Trail, Wm., Asst.-Surg. 91st Highlanders
Prendergast, G. A., Capt. H. M. 5th Bengal Cav. 1*l*.
Gregson, J. D. Ensign, 40th Regt. 1*l*.
Hooker, F.E., Esq., Med. Dept. 1*l*.
Morton, G. de C., Ensign 6th Regiment. 1*l*.

ARMY INDUSTRIAL EXHIBITIONS.

By Captain Frank Bolton, 12th Regiment, F.R.G.S., Assoc. Inst. C.E.

When we consider that the British soldier of the present day has a great portion of his time unemployed, it becomes a question of no little importance to inquire how this leisure time can be occupied profitably, or, at any rate, in such a manner as to prevent the many evils which idleness necessarily induces, and which are so highly detrimental, morally, physically, and intellectually to any man, no matter whether he may be engaged in military or other duties. With a view to the attainment of this very desirable end, much has been done within the last few years, by the establishment of reading and recreation rooms, gymnasia and soldiers' institutes, in addition to regimental schools, and no doubt exists, but that, by their instrumentality, the moral and mental condition of the soldier has been considerably improved, still, as all must admit, who have any intimate knowledge of the interior economy of barrack life, there is even now a something wanting to occupy the attention of a man who has many hours nearly every day at his own disposal. I will take, for example, the ordinary daily employment of the duty infantry soldier in permanent camp or garrison, as representing the greater portion of the army.

He is compelled to rise early; and during the summer time attends drill for an hour or so before breakfast about twice a week, his other daily duties or parades might on an average be considered to occupy

about three hours. After this he dines, and having cleaned his arms and accoutrements thoroughly, and perhaps attended a roll-call parade, he has finished for the day. In the winter months, one hour's drill in the forenoon and one in the afternoon, is about as much as is exacted from him.

Of course, when required for guard, picquet, or other regimental duty, he may be longer engaged, but as a rule between réveillée and retreat, one half of the day is entirely at his own disposal.

Now if he is a reading man, and of steady or studious habits, he will probably go to the library or to school, or amuse himself with a book in barracks, but the greater number of the men go out for what they call a walk, but in reality to visit the public-houses, music and dancing halls, and such like places, the result being in all cases a complete waste of time, and in many cases, drunkenness, rioting, and absence.

It is a mistaken notion that many entertain, that the character of the common soldier is degraded, and that all efforts would be unavailable to render him an intellectual and civilised member of society.

It must be admitted, that, in many instances previously to joining the service, he is thrown upon the wide world without a friend, and without any definite pursuit, in which he can employ his energies. He therefore enlists, and passes a life, when there is peace, in comparative idleness, and without any specific object in view, but the mere passive observance of the duties which are enforced upon him. But ought we not to believe the human mind to be so constituted by a superior Being, that under favourable auspices, and Christian philantropy, amidst whatever difficulties and disadvantages mankind may labour, by proper and judicious treatment, and holding out opportunities tending to their amelioration, they would respond and meet, half way, the advances that are made to them? Prejudice may be very strong, but experience has, in innumerable instances, proved how far it may be misplaced, and how soon, by making use of proper means, *that* prejudice can be removed. Our greatest discoveries have met with the greatest opposition, but how soon this opposition ceases when success attends our attempts? Who would believe there was a world existing in the far west, when Columbus first made his application for support to the several monarchs of Europe? Who could ever have anticipated a few years ago, the improvements which science and indomitable perseverance have achieved with regard to steam, railways, telegraphs, and other momentous advantages, which now astonish and benefit us? There exists surely no man, in the present age, so completely enveloped in the mists of ignorance, who would oppose a system for the enlightenment and advantage of so numerous and important a portion of the community as our British soldiers.

To my certain knowledge, there is no class of Her Majesty's subjects more open to improvement than the subordinates of the army. But few efficient means have hitherto been adopted, to give them a fair trial. It is true some steps have been taken, which have already been attended with very good results. This fact, then, should animate us to

further attempts, and stimulate our exertions to effect so desirable a consummation as the moral and mental improvement of a large, a useful, and an indispensable class of mankind.

There can be no doubt but that the soldier, when he finds himself an object of consideration and esteem, will not be wanting, on his part, to manifest a grateful feeling, and show himself worthy of the confidence reposed in him. At all events, it is a duty incumbent on ourselves, to make the attempt. Even should we fail, we should have an inward satisfaction of having made the trial, but I am perfectly convinced there need be no fear of any failure.

Having thus briefly endeavoured to prove the claim which soldiers have upon our regard and sympathy, let us, in the next place, devise and carry out some plan for bettering and exalting their position. Many of them were possessed of some craft, or means of obtaining a living, before their enlistment. Some of them have been skilful artisans, and are still well acquainted with their avocations as tradesmen. Let then some well-conducted system be introduced, under the superintendence and encouragement of their officers, which shall promote a habit of industry and emulation amongst them, and there can be no question but that much of their leisure time will be devoted to creditable and useful employment, and crime and misbehaviour thereby be diminished.

By means of Industrial Exhibitions, a fair opportunity would be opened for them to exercise their ingenuity. Let these Industrial Exhibitions be periodically held, prizes be awarded for skill, and proper remuneration for labour, and no doubt, the results would be most beneficial, for wherever the soldier may be located, he will find he has specific and praiseworthy means of employing his superflous time, and whilst he is occupied in a pursuit that must produce a pleasure in his own breast, he is also gaining the approbation and encouragement of his superiors.

As Government has already done so much to provide amusement, recreation, and means of mental and bodily improvement for the soldier, by the introduction of the institutions I have just referred to, surely it is not too much, to expect that the soldier himself should do something to contribute towards the same end, and I feel fully convinced that he would do so, if properly encouraged and directed by his officers. Subservient as he is to discipline, he will *not* take the initiative, but only let him have the way pointed out to him and he will follow it willingly and cheerfully without expectation of further reward than the well-merited praise of his superiors; how much more he will do so, with the prospect of reaping a pecuniary benefit, I need hardly say. Now there is nothing to prevent the periodical establishment of Regimental Industrial Exhibitions, which may be entirely self-supporting, and the plan could be carried out without in any way interfering with the efficiency, discipline, or interior economy of a regiment. The objects of these Exhibitions would be the bringing to light the ingenious contrivances of working men, to show that hours well improved (instead of being spent in idleness or worse still, in the canteen or public-house) may produce results astonishing to the men

themselves, to keep mechanics and those who have been brought up to certain useful trades in practice, so that when required their services might be made available for the benefit of their comrades, and to develope such latent talent, as may be now lying dormant amongst the men, of which I have every reason to believe there is much more than is generally imagined. Now we must consider these points in a military sense, and inquire how far they can be carried out without clashing with the present system of barrack life, and also what amount of actual good or benefit either to the soldier himself, or to the service generally, might be expected to accrue therefrom, and to enable a better conclusion to be arrived at, perhaps it will assist us if I here give a history of the origin, progress, and objects of the Exhibition, made by the 2nd battalion of the 12th Regiment stationed in the Richmond Barracks at Dublin, in January last.

In October last year, the idea was first thought of by Colonel A. Ponsonby commanding the battalion, who, after having submitted it for the consideration of several of his officers, and being assured of their cordial co-operation, convened a meeting of the soldiers of the regiment, in the reading-room of the barracks, which meeting was numerously attended, and the project was then thoroughly explained to them.

1stly. The Exhibition was intended to give those who were willing to work for it, something to amuse and instruct them during their leisure hours.

2ndly. Such articles as they contributed were to be sold at a price a little above their actual cost, as the object of the Exhibition was employment, not profit.

3rdly. To show the public generally that the soldier was not a useless member of society.

After this explanation of the project, and the scheme having been warmly taken up, a committee was formed consisting of four officers, and three non-commissioned officers, with the commanding officer as president, two of the officers taking upon themselves the duties of secretary and treasurer: and it was left to this committee to devise means, and carry out the objects of the Exhibition.

The first step taken was to circulate amongst the officers a guarantee list, so that in the event of failure all expenses might be covered; this call was warmly responded to, and over £150 was voluntarily guaranteed by the officers, and about half this sum advanced from time to time as required, to meet the current expenses. The committee then divided itself into two sub-committees, each taking a wing of the regiment, and they collected the names of all the intended exhibitors, the description of the articles proposed to be exhibited, and the probable space such articles would occupy.

When all the exhibitors' lists were collected, the articles were arranged into nine classes, under the following heads:—

Class 1. Comprising carpenters' work and cabinet-making.

Class 2. Military engineering instruments, accoutrements, and equipment.

Class 3. Leather-work, &c.
Class 4. Men's needlework and clothwork.
Class 5. Hardware, jewellery, models, &c.
Class 6. Photography, drawing, and miscellaneous articles.
Class 7. Women's needlework, embroidery, &c.
Class 8. Work done by the children and infant school.
Class 9. Armourer's work.

A statement was then prepared of all the materials required by the intended exhibitors, as also the tools and instruments necessary to enable them to execute their work.

This statement was of a very miscellaneous nature, and as it was decided that it would be unwise to trust the men with money to purchase the materials and tools for themselves, it was resolved to procure them from the tradesmen in the town, by written orders signed by two members of the Committee; that is, by the member to whose wing the exhibitor belonged, for whom the requisition was made, and by the Secretary. The tradesmen's bills were rendered weekly, and duly paid by the treasurer, after having passed the Committee. All the carpenters were set to work in a spare barrack-room, where a turning-lathe and other necessary appliances were placed, the senior non-commissioned officer, or oldest soldier present, being responsible that good order was preserved.

The men employed in leather work, worked in the shoemakers' shop; those doing cloth work, either in the tailors' shop or in their own barrack-rooms, while a second spare room was set apart for the other exhibitors, such as those who were making models, hardware, accoutrements, and articles of equipment.

A printing press was set up in the orderly room, and part of an officer's quarters was turned into a photographic school.

Thus, about the middle of October, everything was got fairly in train, and the making of the various articles commenced, the men working with zeal and ability, and evidently much to their own satisfaction. As each article was completed, it was brought in, and delivered over to the care of the Committee, who marked it, estimated its actual cost, added a percentage thereto for general expenses and profit, and then placed it carefully away until the time of the exhibition, which it had been decided, should take place on the 12th January. During the time the men were at work, they were constantly visited by the Committees, who afforded them any assistance they required.

I may here remark that many of the exhibitors provided everything they required for themselves, and some needed, and received, only partial assistance.

It was at first intended to have held the Exhibition in barracks, but as no room could be obtained suitable for the occasion, it was ultimately decided to hold it in the Rotunda.

There were many difficulties to contend with in carrying out this scheme, such as officers going on leave, men being away upon furlough, &c., but as all who took an interest in it, used their utmost exertions to command success, these difficulties were overcome, and the Exhibi-

tion promised to be of so interesting a nature, that Colonel Ponsonby submitted it for the approval of the General commanding the troops in Ireland, Sir George Brown, who at once gave his sanction for its being thrown open to public inspection. His Excellency the Lord-Lieutenant kindly consented to patronise the scheme, and open the Exhibition.

In the beginning of January the intended exhibitors numbered over 70, while the articles to be exhibited were more than 250.

The Rotunda having been hired for one week, it was appropriately decorated with military devices and banners; the arms and armour used for the decorations having been lent for the occasion from the Dublin Armoury, by the Right Honourable the Secretary of State for War.

As the day approached upon which the Exhibition was to open, much anxiety for its success prevailed, but everything was so organised by the Committee, that no hurry or confusion occurred. All the articles were duly placed on stalls under their respective classes, and stall-keepers appointed from the exhibitors, who were furnished with price lists of every article under their charge, and written instructions as to the sale and delivery of the goods. The Exhibition was then opened to the public at 12 o'clock on Tuesday, the 12th January. On the arrival of His Excellency the Lord-Lieutenant at the Rotunda, he was received by a Guard of Honour, and while he was entering the building, the band of the regiment played the Regimental March, and continued playing until His Excellency was seated on the dais. Then Colonel Ponsonby stated the objects and purposes of the Industrial Exhibition in the regiment under his command, and His Excellency having replied thereto, the National Anthem was sung by the band and chorus of the regiment, at the conclusion of which the barriers were removed, and the Exhibition declared duly opened. The band next performed an opening march, composed expressly for the occasion, by the band-master of the regiment; and His Excellency and suite, and other visitors proceeded to inspect the various articles exhibited.

This formed the opening ceremony.

At a luncheon given by the officers on this occasion to the Lord Lieutenant and the garrison, his Excellency in his speech alluding to the ingenuity and enterprise of the men, said, "They have shown us "to-day they are as good proficients in the arts of peace, as we are "sure they would be in those of war, and I think we all owe them a "debt of gratitude for showing us what can be done in the internal "life of a regiment, because I conceive it to be very much owing "to the encouragement and development of the regimental system, "that the characteristics and peculiar efficiency of the British army "belongs."

The Exhibition was kept open for four days from 12 to 5, and from 7 to 10 in the evening; the soldiers of the garrison being admitted gratuitously from 5 to 7 o'clock. The price of admission was half-a-crown on the first day, and a shilling afterwards.

I have thus stated the origin and progress of the Industrial Exhibition of the 12th Regiment, and will now say a few words

about the articles exhibited, and the results which attended the enterprise.

In the first class, the articles of cabinet-making and carpenters' work exhibited numbered 34, being the work of 8 exhibitors, and consisted of portable washing-stands, officers' tables, book-shelves, sets of pigeon-holes, cigar-boxes, racket-bat cases, stereoscopes, fives bats, camp-stools, paper-knives, specimens of fretwork, billiard cues, brackets, and sundry other articles.

The workmanship in this class was particularly good, and every article was sold on the first day of the Exhibition.

In addition to this class, 4 exhibitors combined their handicraft together, and produced in the course of a few hours, that which formed one of the most attractive features in the Exhibition, viz., a complete model of a compartment of an officer's hut, containing every requisite, as a table, two chairs, washing-stand, bedstead, cupboard, shelves, clothes-pegs, portable stove, and cooking apparatus. All these articles were substantially and well made, and the experiment was to show, that in the event of the necessity arising, an officer need not look further than his own regiment for those necessaries and comforts which, in a distant clime, or on service in the field, he might otherwise have been a long time without.

In class 2, were exhibited all such articles as came under the heads of military engineering, instruments, accoutrements and equipments, the number of exhibitors were 11, and of the articles exhibited 24. One of the articles of accoutrement was the invention of a private in the regiment, and is quite worthy of mention. It was a proposed improved ammunition pouch, and new method of carrying the same by which the pressure would be taken off the chest. The bottom of the pouch was made to open by compartments, and by merely pressing a button the flap fell down, and a packet of ten rounds of ammunition was received in the hand, for distribution in the ball-bag. The straps for carrying the pouch came from the centre to the side of the pouch, crossing at the back, and passing over and round each shoulder. Sir George Brown took particular notice of this improvement, and complimented the inventor very highly on the talent he had displayed in its contrivance (for he not only conceived the idea, but carried it out himself). There were also exhibited in this class a model of an improved movable target, some electric and scientific instruments, a proposed new method of carrying the knapsack without shoulder-straps, thereby removing the pressure from the chest. A model of a fortified house and bridge, an improved bullock trunk, containing an officer's camp-bed complete. A suit of an infantry soldier's clothing, as it should be in the opinion of the non-commissioned officer who made it, and which in many respects was vastly superior to the clothing as it now is, improved regulation boots, gaiters, braces, and stocks, and a portable field writing-case.

In all these articles, much ingenuity and ability were displayed, and many of them were of very superior workmanship.

In class 3, which consisted of leather work, &c., there were 12 exhibitors, who contributed 26 articles, comprising boots, shoes, slippers,

a pony saddle, cigar-cases, cricket-bat-cases, whips, and gaiters. One serjeant exhibited a most ingenious pair of slippers, with the upper part all in one piece. A private produced some braces and stocks, well worthy of remark, being in every respect equal to, and sold at a less price than the ordinary regulation articles. The other articles of interest in this class were some capital pairs of gaiters, and boots of excellent workmanship.

The present regulation gaiter is both unsightly and uncomfortable, and a non-commissioned officer brought forward a reversible gaiter of his own contrivance, consisting of stout white canvas on the one side, and brown leather on the other—the first for fine weather, and the latter for wet. The gaiter was fastened without buttons by means of a lace; and, altogether, was very sightly, and promised to be of much greater durability than the one at present in use in the service.

The fourth class comprised articles of men's needlework and cloth-work, and in this class the chief features were the bright colours of the patchwork quilts and rugs made from pieces of old regimental clothing, the making of which had afforded pleasant occupation for some months to many men, who would otherwise have been idle. Some of these quilts were of good workmanship, and the designs were both original and effective, the cloth being cut up in little squares of about an inch in size, and sewn together in the shape of stars and other devices, and employing in their construction more than 1,000 or 1,500 pieces, according to the size of the quilt. There were eight of these rugs or table-covers exhibited, and they realized prices of from £2 to £6 each. The other articles exhibited in this class consisted of Berlin wool hearth-rugs, wearing apparel, and bead work, of which there was a goodly display.

Class 5, representing the work of the men in hardware, jewellery, and models, contained a most interesting assortment of articles. A pile of gold exhibiting the amount of gold-leaf obtained from half a sovereign, prepared by Private Bewley (a gold-beater by trade), was very much admired and was purchased by His Excellency the Lord Lieutenant. This exhibitor also showed a case containing all the articles used in his trade, and gold in the various stages of gold beating, from the nugget to the perfect leaf. Next in point of interest came some thermometers and crucifixes, made from slate, and their novelty and excellent finish, well entitled their maker to the amount of praise he received. There were altogether 27 exhibitors in this class, and the other articles shown were kaleidoscopes, mountings for riding whips, a model of a coach of the Elizabethan period, a sectional model of a merchant barque, fishing-rods, improved fire-fan bellows, a model of Richmond Tower, a French clock mounted on slate and alabaster, a stand for a lamp, some dog whistles on a new principle, a pair of razors, inkstands, a sun-dial, a lever clock and watch, a set of marquoise scales, portable brass clothes-pegs, some bracelets and gold and silver scarf pins, and other ornaments.

Class 6 consisted of photography and drawings, and other miscellaneous articles. Here there were 12 exhibitors, and the specimens

of art exhibited, comprised three large frames of *cartes de visite*, groups, and vignettes, all taken by photographers in the regiment; two excellent drawings in chalks, a map of Ancient Greece, paintings in water-colours and military drawings, coloured photographs, sketches in oil and water-colours, a collection of 256 botanical specimens collected in the Crimea after the fall of Sebastopol, by Dr. Birnie, and specimens of printing. Of the exhibitors in this class four were officers, and eight non-commissioned officers and privates.

(There is a photographic school in the regiment, in which all the photographs were taken by a corporal and his assistants, who were taught the art since joining the service.)

Classes 7 and 8 perhaps were most attractive to the lady visitors of the Exhibition, and if we may judge by the rapid way in which all the articles were disposed of, we need not be ashamed of the handiwork of the soldiers' wives and children. The largest, and consequently most conspicuous objects, were some beautifully worked children's dresses, some excellent shirts for the soldiers, and other specimens of useful and ornamental needlework; and so warmly was the subject of the Exhibition taken up by all classes in the regiment that the interest actually extended to the little children from four to ten years of age, and the infant school produced sufficient work to entitle it to a class for itself, and actually to cover a table of no ordinary dimensions.

In class 9, consisting of armourer's work, the armourer-serjeant exhibited (all of his own making) a breech-loading double barrelled gun, a double gun (muzzle loading), two keeper's guns, and two single barrelled guns. This artificer also worked during the time the Exhibition was open at his portable field-forge. A printing press having been set up in the regiment, it was brought to the Exhibition, and one of the drummers, assisted by a private, was kept employed in striking off copies of the *East Suffolk Gazette* (the regimental newspaper), all of which were rapidly purchased; programmes of the music performed by the band, and copies of the book of glees sung by the men of the regiment for the amusement of the visitors were also printed.

Some of the men executed very fair specimens of fret sawing during the time the Exhibition was open; and as they cut out crests and initials on paper-knives, &c., very cleverly, these articles were much in request.

Such was the Industrial Exhibition of the 12th Regiment, and if we may be permitted to draw an inference from the numerous and fashionable attendances, and the favourable opinions publicly expressed, it met with a complete and distinguished success. The number of paying visitors who attended the Exhibition were altogether 1,828, of whom 478 paid half-a-crown, and 1,350 one shilling each; there were besides great numbers of the soldiers of the garrison, all of whom were, of course, admitted free.

The expenditure consisted of the hire of the Rotunda (an expensive item, by-the-by, of £58 odd), gas, purchase of materials, car and van hire, and the profits to exhibitors, amounting altogether to £354 6*s*. 8*d*.

The receipts by admissions, sale of articles, &c., came to £309 16s. 8d.,

and the balance of £44 10s., required to meet the expenditure, was subscribed by the officers of the regiment, out of the guarantee fund.

The funds at the disposal of the committee did not admit of their awarding pecuniary prizes, and purchasing tools, as was originally intended; but certificates of merit were given to the best workmen, which were received by them with evident satisfaction, and especially by those who had previously been men of notoriously bad character, in which class were found more than one of the best artizans; and it is gratifying to know, that during the time the work of the Exhibition was in progress, and subsequent thereto, these men have been steady and well behaved; while the general amount of crime in the regiment was at the same time considerably decreased.

As a sequel to the history of the Industrial Exhibition of the 12th Regiment, I will give an extract from the *Gazette* published by that corps, which is the newspaper I have already alluded to, and which cannot fail to be heard with interest. Speaking of their industry, the editor says:—

"It is an exhibition of our industry—industry carried on in hours "that heretofore we have wasted in riot and idleness; industry that "has benefited us in health and feeling, industry that will prove to "the world at large, and to our own personal friends, that soldiers "though we be, we have not forgotten the trades and teaching of our "early life, and that we are fit for something more than 'mere food for "powder.' One of the first, and, we think, the most important features "in our Exhibition—a feature which was early impressed upon the men "of the regiment, and has been attended with the greatess success— "was that the Exhibition was open to all ranks, from the colonel to "drummer-boy, from the recruit to the veteran of nigh thirty years' "service, from the latest denizen of the cells, to the proud owner of "five good conduct stripes; to one and all was our Exhibition open; "character was to be of no account, for, indeed, it was mainly for the "sake of those of indifferent characters, and whose weakness and "natural infirmities led them into temptation, and inevitable punish-"ment and disgrace, that our present undertaking was attempted. "Many there were who were without funds to purchase the materials "for carrying out their designs, and as it would have been mistaken "kindness to afford pecuniary assistance to those whose worst enemies "were themselves, a uniform system was adopted of giving orders on "tradespeople in the city through the treasurer, by which means the "required materials were delivered to the men in barracks, thereby "saving them a long walk, and keeping the weak from temptation. "And here let us express our thanks to the tradesmen who have so "willingly assisted; to all the committee we are indebted for their "assistance; such assistance has only been made use of by a com-"paratively small portion of the exhibitors, and to those who have "worked without it no small credit is due, as many have worked "with indifferent tools, which has rendered their labours all the more "laborious. Far be it from us to disparage those who have obtained "assistance; all have worked with ready zeal; all have been animated "by the desire to uphold the credit of their regiment; and it is no

" small gratification to reflect, that limited as our time has been, in no " way has the discipline of the regiment been relaxed; on no account " has working for the Exhibition been put forward as a plea for exemp- " tion from military duties. That success has attended the Exhibition, " is now an indisputable fact; it has realised sufficient, if not more, " than will pay all expenses, and, therefore, every encouragement is " given to other regiments to have similar Exhibitions. We trust that " such will be the case, as they will repay not only the exhibitors for " their labour, but the visitors by the instruction and pleasure they " will derive from attending them."

Not long after the termination of the Exhibition of the 12th Regiment at Dublin, the following paragraph appeared in the naval and military intelligence of the *Times*, by which it will be seen, that the example shewn on that occasion, has already attracted considerable attention in other military quarters:—

" The success which has attended the Exhibition of the 12th Regi- " ment at Dublin, has induced the authorities at Aldershott to institute " a similar project, in order that the troops may have some profitable " occupation during their spare hours, as well as to afford them an " opportunity of displaying their abilities in inventing and making " articles, which will be both serviceable to the purchaser, and remu- " nerative to the maker.

" The principle object in view, however, is to lessen the amount " of crime. The project is heartily entered into by the officers, and " there is not the least doubt that it will prove quite as successful as " that at Dublin. Several meetings have been held during the present " week, at which it was decided that the officers commanding such " regiments, corps, and departments, as may be willing to take part " in the Exhibition, be the members, and form a general com- " mittee. Lieut. Gen. Sir J. L. Pennefather, K.C.B., has consented " to be president, and general officers commanding brigades Vice- " Presidents. Lieut.-Col. the Hon. H. Clifford, V.C.A.Q.M.G., Lieut.- " Col. Lennox, V.C.D.A.Q.M.G., and Major Hammersley, Director of " Gymnastics, were appointed Secretaries and Capt. Maclean, Brigade " Major 1st. Brigade, and Capt. Lockhart, D.A.A.G., Treasurers. " Every regiment taking part in the exhibition will be regulated by " a court formed among themselves, who are to make their own neces- " sary arrangements under the direction of their commanding officer, " in such a manner as he shall see fit. Each regiment will have to " find such tools as may be required by the non-commissioned officers " and men. It was also decided that if any regiment now quartered " at Aldershott, should be ordered away before the Exhibition was " opened, they should still have a right to send articles to be ex- " hibited. The privilege of making and shewing things will not be " confined to any particular class of the military, but will be open to " officers, non-commissioned officers, and men of all ranks, as well as " their wives and children. The articles proposed to be exhibited will " come under the following heads:—Painting, drawing, and pho- " tography. Carving, cabinet-making, and carpenters' work. Military " engineering, instruments, accoutrements, and equipments. Ar-

" mourer's and smiths' work. Leather-work, and needlework, and " clothwork. A space will be set apart for the exhibition of articles " collected by officers, non-commissioned officers, and men during the " course of their service in different parts of the world. The Exhi- " bition will be open in June next, and when the proceedings are " more developed, the committee will decide how long it shall re- " main open. The proceedings are sanctioned by His Royal High- " ness the Commander-in-Chief, and the Exhibition will take place in " the Club-house."

In concluding this paper, it may, perhaps, not be out of place to offer a few observations on the importance of the general application of education to the soldier, forming as it does, the grand means by which the human mind may be ennobled. Without it, we find men shrouded in ignorance which, when their passions are excited, renders them prone to, and capable of, committing any crime. Nature is, unfortunately, attended by evil as well as good propensities, and often we find the former predominate most fearfully over the latter. We need not confine our observations to any isolated class in any climate or district of the globe; evil is sure to exist everywhere, whether it be in countries enjoying the best laws and privileges, or in the resorts of savages of the most degraded and repulsive habits. But still the evil if not totally eradicated, will be greatly modified by the influence of education. We need merely to observe the grand and astonishing effects produced in our own country, where innumerable Institutes exist, pouring forth learning and improvement through a thousand streams, and diffusing their influence over the remotest regions of the world.

Now when we speak of education in its general and widest sense, we do not restrict our attention to the instruction dispensed within the walls of a college, or the information disseminated through a country by the influence of literature. Education takes a more comprehensive range, and signifies the moral culture of the mind, and a judicious application of the means best calculated to occupy our mental and physical powers, in such a manner as to be conducive to our own improvement, and make us capable of regarding the welfare of our fellow-creatures.

The man of classical erudition and nice discernment, is capable by his own exertions, of pursuing occupations agreeable to his own taste, and without which he is lost to himself and all around him. But there are other classes of the community who, in their peculiar sphere, are as indispensable to the general commonwealth as the highest and best instructed in the land.

I believe, if I have not been wrongly informed, that the scientific and amusing game of chess was originally invented by a philosopher, under the impression that he could inculcate on the mind of his emperor, who was a tyrant, the grand moral fact that his own safety depended as much upon the lowest subject in his realm, as upon those in a more exalted position; and there are few military men, being chess-players, who are not aware that the king must become check-mated by the neglect and consequent loss of the pawns.

The inference to be deduced from the above must be self-evident to all who hear me to-night. The meanest subject in our land has a position as well as the most noble and learned. In fact, were it not for the lower classes of society, what would be the value of the highest?

The main strength of a nation depends upon the mass, as the chief success of an army depends upon its subordinates. Generals may be qualified to command, plan mighty exploits, and gain splendid victories, but of what use would be their qualifications without the materials for the accomplishment of their projects?

Then does it not seem evident to all thinking men that every effort should be directed to the improvement of those upon whom so much depends? Is it not feasible to expect that they will more effectually and promptly perform their duties, when they find themselves regarded with interest and respect?

When a soldier finds himself treated with philanthropy instead of being merely placed on a footing with an automaton, he will immediately begin to respect himself, and, as a natural consequence, will esteem those whom he considers well-disposed towards him. When *this self-respect* therefore is once inspired and established in the breast of a soldier, he may be considered on the eve of a grand moral revolution, and there is no sacrifice too great for a brave man to encounter, when he finds his character at stake.

The practicability and usefulness of periodical industrial exhibitions in the army will diminish idleness by encouraging industry, they will revive and strengthen the dormant talent of the soldier, and it is hoped that they will enable him usefully to employ his leisure hours whilst in the service of his country, and, should it so happen, as unfortunately it often does, that he should through any circumstance become disqualified to perform the functions of a soldier, he can then fall back upon his former occupation, which he thus will not have neglected, or by the agency of such Exhibitions he will have acquired some trade which will thus enable him to earn his own living, and avoid the deplorable condition of being a burden to himself and all around him, or dependent upon such a pension as is totally inadequate to provide the necessaries of life.

In the event of the establishment of Regimental Industrial Exhibitions, let us hope that the objects aimed at will be fully gained, amongst which not the least important, will be the amusement and instruction of the soldier, the means of giving him useful and suitable employment during his leisure hours and the consequent decrease of crime; and thus the *morale* and efficiency of our army cannot fail to be considerably improved.

The CHAIRMAN: Though there are but few members present, I hope we shall have a discussion upon this very interesting paper, or if any gentleman has any remarks to make, we shall be very glad to hear them.

Commander COLOMB, R.N.: I cannot help regretting that my friend, Captain Bolton has not a larger audience to hear the very interesting paper which he has read to us. I am quite sure that the loss is on the side of those who have stayed away. For a naval officer to propose making any remarks upon the subject of Army Industrial Exhibitions may appear a little out of place; but I am one of those who

think nothing is out of place where one can gain knowledge: and the knowledge of dealing with men and keeping up discipline, whether it be in ships or among troops on shore, comes to very nearly the same thing in the end. Men are the same, whether they wear blue or red coats, and the mode of dealing with them must be nearly the same. So far as the subject of Industrial Exhibitions concerns the navy, there is very little to be said, because the want of space on board ship, does not allow the men to put any trade in force, and very few of our blue-jackets coming into the service as boys, know any trade or have been brought up in any. Still there are a great many other ways in which our sailors could be employed. I do not think that sufficient care is taken to employ our blue-jackets in their leisure hours. If we go round the lower deck of any of our line-of-battle ships, or iron-clad ships, we find the watch below, as a rule, asleep; and on board most ships, that is the ordinary employment of the British sailor in his watch below. It is called the necessity of the case; and it is a necessity, because I believe sufficient effort is not made to remove that necessity. When this blue-jacket, who spends his watch below asleep, gets on shore, from mere vacancy of mind he goes into the grog-shop; and the result is that his leave is broken in the morning. When I was at Devonport, I saw some efforts made in the way of supplying, or rather of filling the vacancy in the leisure hour of the blue-jacket in the shape of lectures, concerts and theatricals, and matters of that sort. In the gunnery ship at Plymouth, the *Cambridge*, they have either a play, or a concert, or some amusement that kind, I think once a fortnight. The consequence is, they really find that crime is diminished. There is no difficulty in keeping the men in a proper state of discipline. Indeed, they almost keep them themselves so, simply because their vacant hours are employed; and if their vacant hours are not employed in something intellectual, or in something above the beast, the beast will break out. I wrote to an officer of the Marine Artillery upon this subject a little time ago, knowing that something had been done there in the way of employing their leisure hours with the view of reducing crime and absenteeism. The head-quarters of the Artillery are at Fort Cumberland, about three miles from Portsmouth. The amount of absenteeism among the men was, for that reason, perfectly heart-breaking; the colonel-commanding and the officers could do nothing with it. At last they determined to give the men something to do, something to keep them employed. I will just read you an account of what has been done:—

Extract from Letter.

"I cannot at such short notice give you all the precise facts connected with the effect of the theatre, but it has now been established since November, and continues performances almost weekly—a drama and farce (new). The accommodation was so bad that only about one-third of the gunners and non-commissioned officers at head-quarters could be accommodated. The house has been full to overflowing each night, and the number of absentees more than one-third less than last year, that is, for nine men absent from tattoo, now read five or six; on theatre nights, generally 'all present.' Concerts have also been established which have raised the amusements, skittle-alleys, a billiard-table for the non-commissioned officers, a recreation-room for non-commissioned officers and men, in which bagatelle-boards, draughts and chess are at their service—are always full. This has all combined, together with a Regimental Police, to reduce the number of absentees to about one-half.

"There has not been a Regimental Court-martial held since November.

"The 'Absentee List' is confined now to a certain few men, who are irregular and always will be: if these 60 or 70 men were got rid of we should hardly ever have any defaulters at all, as the bulk of the men remain in barracks, or at all events do not go into the town in the evenings. The places of amusement are always full.

"I think from my experience, about one-third of the men (soldiers) are perfectly steady, with pursuits of their own which keep them straight, one-third are men who require to be amused and employed to keep them perfectly regular; and one-third are men of vicious and idle propensities whom nothing but fear of punishment will keep out of the defaulter's book. Now these last mentioned, have acquired habits of irregularity, as recruits, from a want of employment and amusement, and hence fall from the second to the third grade.

"Of the class of men who join us, I put down one-third of them as naturally steady from their individual characters; the other two-thirds, ordinary mortals, easily led to good or evil, and if not looked after and given something to keep them in barracks, half of these will go to the bad and become irregular men. I am sure that amusements and employments, to make barrack life more homely, would, if properly and carefully conducted, abolish the crimes of absence, drunkenness, and consequent insubordination; and the continental system with regard to garrison towns, would give a better tone to the army generally. Their mental condition would be improved in the same ratio as their physical condition. The want of attention to these two things, ruin large numbers of our men—I mean the British soldiery."

I have very little more to say. It may be thought perhaps, that this does not bear upon the point. But I think it does, because Captain Bolton at the end of his paper touched upon the general question; and the general question is the employment of the British sailor and the British soldier in his leisure-hours. I think Captain Bolton has brought forward the very best mode of employing them that I have ever heard of.

The CHAIRMAN: I quite concur in the importance of Captain Bolton's paper, and I do not think anybody could take exception to Captain Colomb's remarks, on the ground of their inapplicability. With regard to the government of men, it is most important that it should be, as other things are, reduced to a science. I am not prepared to go with Captain Colomb to the extent he does, with respect to the impossibility of organising any scheme for the employment of men in the navy. I am sure, as he has stated, and as Captain Bolton has suggested, there is a far superior way of employing their minds than by mere theatricals. Apart from any higher ground of objection, there is this simple one, that theatricals only occupy the minds of the people during the performance, except those who have to sustain the characters. Captain Bolton's plan embraces every man that chooses to come forward, which is very important. When I look back to the early days of the navy, I remember that the importance of occupying men's minds was quite recognised by the old school of officers. But their expression was, "Keep the devil out of their minds;" and the way they set about it was to put the men to underrun cables, clear hawse, and holystone decks on Sundays, leaving no resource for the week-days. It has been well said by a philosopher, who has left his mark upon his age—perhaps no more indelible mark has been left upon his age than by him—that the only way of getting rid of a wrong habit is by "the expulsive energy of a new affection." This is in some measure what has been suggested by Captain Bolton. Any gymnastics of the mind are important, particularly when they keep men engaged, fill up a vacuum, and prevent a recurrence to bad habits. Sin thought over, would find its execution; so our men break out of barracks and get out of their ships. It is more important, now that war is made a science, not to have men who are only food for powder. We must have men that are intelligent enough to use the weapons put into their hands. This is the kind of education that is desirable. Men thus trained will be not only more skilled in the use of their weapons, but they will be better qualified to provide for themselves and protect themselves against the inclemency of the weather. The manifest consequence being that they suffer very grievously, because they do not possess the most ordinary and trivial kind of information to enable them to select ground for encamping, or to form trenches to carry off the water—things that would suggest themselves at once to trained minds. I have pleasure in renewing my acquaintance with the 12th. I was very much struck with the characteristic difference between the 12th Regiment and some other regiments that I met. I took one wing of that regiment to the Cape of Good Hope in 1851, and I have a very agreeable reminiscence of the officers. Another thing which struck me was that my men at once fell into a brotherly kind of communication with the soldiers. With the men of other regiments that I have embarked, my men would not associate at all. They looked upon them as inferior people. Now, I contend it would be for the interest and for the economy of the country if the status of the soldier and sailor were raised. A higher class of men would come into the service, and you would find that a lesser number of men would do the work now required. We should have less crime. A number of the men now

spend half their life in hospital from dissipation, or under punishment, so that you have to strike off a large per centage from the effective force of the army and navy because of this. Get rid of that evil, and then you might have a smaller force and yet a more effective one. Sailors, arising out of the circumstances that they have to make their own clothes, are more skilled than soldiers are. There are some idle ones who will not do that, but pay others to do it for them. I remember some years ago we captured a slaver on the coast of Africa. We had to go down to the Cape, where, it being winter, it was very cold. All these slaves were naked, male and female. The vessel was not seaworthy; what was to be done in the matter? We must clothe them. We got the hands up, and the stuff from below; the fellows sat to work, cut up the materials, and in a very short time they made the clothes. How these poor creatures would have suffered if the men had said, "We can't do anything of the kind." What a condition they would have been in. Just this difficulty occurred in some cases in the Crimea. The men were frost-bitten, and afflicted in other ways, just for the want of a little mechanical knowledge, which, according to this proposition of Captain Bolton's, would be systematically introduced into the army. It is also an important consideration, now that we are enlisting for a short term of service—ten years' men. Men, in many instances, from the loss of a thumb, or the loss of a finger, have become disqualified for the service, and not having been brought up to a trade are thrown out of work, and have only their pension of six pence or less to live on. There is no doubt if these men were to acquire trades, or were to keep up the trades they had once learned, that they would have no difficulty in finding employment. We are much indebted; indeed the whole army and navy are indebted to Captain Bolton for this paper. I am happy to say that, notwithstanding the small number present, the paper will receive considerable currency in our Journal. The meeting will allow me to return our thanks to Captain Bolton for the interest, and for the instruction, he has afforded, and the new ideas he has conveyed by this useful paper.

Captain BOLTON: I wish to be allowed to remark that the merit of the scheme is not due to me. I was merely a willing assistant in carrying it out. The idea originated with Colonel Ponsonby, and it was worked out under his immediate supervision; therefore, the whole merit of the scheme, together with all the suggestions, properly belong to that gallant officer.